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Cultural landscapes and behavioral transformations: An agent-based model for the simulation and discussion of alternative landscape futures in East Lesvos, Greece

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Abstract

The concurring forces of agricultural intensification and abandonment have been identified as some of the more prominent and polarizing drivers of landscape change in Europe. These transitions may induce deterioration in landscape functioning and character, particularly in cultural landscapes demonstrative of evolving human-environment dynamics having sustained multiple environmental benefits through time. Cultural and behavioral motives are significant root influences to such landscape transitions, yet efforts to address landscape degradation are often hampered by a failure to account for the heterogeneous decision-making nature of its agents of change and the inherent complexity of socio-ecological systems. Novel techniques are required to further disentangle responses to multi-level drivers and discuss alternative landscape development trajectories. Agent-based models constructed by means of participatory approaches present increasingly applied tools in this context. This study sought to capture and model the future perspectives emerging from presently occurring farming discourses in the region of Gera (Lesvos, Greece), characterized by persistent abandonment of its traditionally managed olive plantations. We constructed an agent-based model iteratively in collaboration with the local farming community and experts in landscape research. Empirical findings informed the model through the construction of a farmer typology, revealing a heavy reliance of the farming community upon sectorial profitability, prevalent cultural farming motives and emerging landscape initiatives. The model examined the de-coupled role of agricultural profitability and landscapes initiatives in shaping the behavior of land managers, mapping alternative landscape futures over a period of 25 years. Model results illustrate increased profitability alongside action by landscape initiatives alone can reverse abandonment trends within the simulated time frame. The hypothesized ability of landscape initiatives to maintain and promote a cultural drive amongst adhering farmers is crucial for securing behavioral transformations towards professionalism. This study confirmed agent-based modelling to be intuitively received by stakeholders who significantly contributed to model structure refinement and the rejection of a status quo scenario.

Keywords

cultural landscapes; collective action; scenarios; decision-making; landscape change; abandonment

1 Introduction

Influenced by human activity, sustaining of traditional heritage elements and framed according to experiential and intangible values, cultural landscape definitions reveal layered and subjective notions, where physical manifestations of cultural processes and the natural environment meet human beliefs and conceptions (Jones, 1991). Cultural landscapes thus exist within porous and dynamic contexts to which societal and behavioral transformations are integral components (Ohnesorge et al., 2013; Plieninger et al., 2016, 2013). Processes of globalization and urbanization, for example, have occurred alongside changing societal needs and values, setting new prioritization agendas for the ways landscapes are managed, protected and used (Antrop, 2005). As with all landscapes in Europe, cultural landscapes have been progressively "re-organized" in time in a transformative process concurrently resulting in their valorization (establishment of UNESCO World Heritage Cultural Landscapes (Rössler, 2006)) and vulnerability (declining landscape functioning due to increased agricultural intensification or abandonment (Plieninger et al., 2016)). Cultural heritage embedded within Mediterranean agricultural landscapes is exemplifies this dual phenomenon, where, despite widespread recognition of the multiple services they provide (Plieninger et al., 2013), traditional agricultural landscapes are gradually being lost to abandonment to the detriment of tourism, rural vitality and specific ecosystem service (ES) provision (Fleskens, 2008; Sayadi et al., 2009; Schmitz et al., 2007). Land-based solutions countering landscape degradation are all too often hampered by a failure to account for the inherent complexity of socio-ecological systems (SESs) (Hoang et al., 2006). Accounting for sociological perspectives in the analysis of landscape change can disentangle such complexity via the identification of actors and organizational properties which catalyze such transformations (Rudel, 2009).

In the context of cultural landscape change there is a pressing need for the consideration of behavioral changes which may ensue as a result of collective action and local initiatives emerging "bottom-up" within communities, alongside those brought about by large-scale operating macro-drivers (Selin & Schuett, 2000). This is particularly relevant in a time of increased proposals for an integrated landscape approach and discourses promoting the establishment (or fostering) of Integrated Landscape Initiatives (ILIs). The definition adopted builds on that of the Landscapes for People, Food, Nature Initiative (LPFN) (Milder et al., 2014) and states that ILIs have to comply with the following criteria: "work at the landscape scale, involve inter-sectorial coordination, develop or support multi-stakeholder processes, be highly participatory and work mainly on a non-profit basis" while "fostering the provision of a broad range of landscape services" (Plieninger et al., 2014). ILIs stem from an understanding that collaboration amongst institutions at all levels is necessary for fostering the social and cultural capital vital to heritage conservation and sustainable land management (Prager, 2015). Facilitating institutions, such as ILIs, are required to play a bridging role between involved stakeholders, transcending disciplines and scales, and place strong emphasis upon capacity building for the self-sustainment of feedbacks to social capital building (Cash, 2001; García-Martín et al., 2016; Wagner and Fernandez-Gimenez, 2009).

These types of integrated or collaborative initiatives have however rarely been explicitly incorporated within computational models of land use and landscape change (Doran, 2001). Advances in landscape science have seen emphasis on the development of models in close collaboration with local stakeholders, whether through the use of companion modeling approaches, on-site interviews or stakeholder workshops (Janssen and Ostrom, 2006; Voinov et al., 2016), favoring the use of models for the discussion of local management options and the design of spatially explicit explorations (van Berkel and Verburg, 2012).

A specific type of modelling, agent-based modelling (ABM), has gained ground in land-use change science precisely as a means to explore management interventions within complex SESs (Filatova et al., 2013). Inherent to ABM research is the placement of the agent, or actor, “center-stage” in determining landscape transitions, setting driving forces as components of an environment within which the actor operates and undertakes certain decisions (Hersperger et al., 2010). ABM thus focuses on modeling the behavioral processes and decision-making of agents, representing the diversity within learning, adaptation, imitation and communication processes that characterize heterogeneous communities. Following a delineation of agent attributes and decision-rules representing the dynamics at play within a system, the ABM runs allowing for a summated representation of individual actions at a wider scale, for example demonstrated in regional land-cover transitions. ABMs are thus valuable in the exploration of alternative landscape futures, where driving forces such as market prices, subsidies and trade regulations can be altered and the resulting impact upon decision-making and land management represented and quantified. Such an approach has been adopted in numerous models, see Gibon, Sheeren, Monteil, Ladet, & Balent (2010); Le, Seidl, & Scholz (2012); Lobianco & Esposti (2010); Schreinemachers & Berger (2011); Valbuena, Verburg, Bregt, & Ligtenberg (2010); Wang, Brown, Riolo, Page, & Agrawal (2013). While ILIs per se have not been investigated by means of ABM, studies have similarly focused on the spread of organic farming or sustainable land management practices (Johnson, 2015; Kaufmann et al., 2009), shedding light on differing modeling approaches for diffusion theory, yet rarely incorporating motivational drivers (Kaufmann et al., 2009). The study of behavioral responses to existing drivers may thus furthermore range to include actions of local mobilization groups in comparison to those of macro-drivers (Caillault et al., 2013).

The objective of the research reported in this paper is to improve our understanding and representation of the interplay between macro-drivers, ILIs and behavioral transformations in the context of cultural landscape change. Towards this objective, this paper investigates the ways in which ABM can contribute to such understanding and promote societal discussion about management options. Empirical evidence informed the model in an iterative development process involving in depth interviews and consultations between and among scientific experts and local farming community members of the municipality of Gera (Lesvos, Greece). The research aimed to illustrate how landscapes are shaped by agent behavior by understanding the heterogeneous land-based decision-making processes of the community, exploring its differing motivational values and attitudes to land management and landscape change. The unravelling of such processes is hypothesized to enable the exploration of alternative futures, leading to an evaluation of how this community and landscape may respond to contrasting scenario storylines with and without consideration of ILIs.

2 Methods

2.1 Case study area description: Gera, East Lesvos

The research aims were explored within the context of landscape dynamics identified in the former municipality of Gera, located along the eastern coast of the Greek island of Lesvos in the northeastern Aegean. The region’s rich cultural heritage is in part preserved in the traditional cultivation of its extensive olive plantations, practiced within what is locally termed a terraced “olive forest”. Olive cultivation in the region was effectively a monoculture throughout the greater part of the 18th and 19th centuries (Kizos and Plieninger, n.d.). More recent trends have however revealed marked demographic and landscape transitions. Gera has witnessed a decline of almost 40% of its population since the 1950s, leaving a consistently negative natural balance (births minus deaths) and a low percentage of active inhabitants, a trend associated with increased agricultural abandonment gradually resulting in a re-wilding of the region to a forested Mediterranean environment (Bieling and Bürgi, 2014).

The existing olive plantations strongly resemble semi-natural systems, playing a crucial role in the balanced delivery of multiple ESs including the enhancement of biodiversity, soil and water conservation and preservation of heritage practices (Kizos and Koulouri, 2010). A declining portion of full-time farmers has left way to part-timers whose household incomes for the large part reside outside of the agricultural sector. While mechanization opportunities are limited because of a sloping and rugged terrain, the sector remains highly reliant upon manual labor, often fed by seasonal immigration fluxes, and has seen little intensification beyond fertilization and irrigation. Limited alternative employment opportunities are keeping a significant portion of the local population to olive cultivation, yet few successors are willing to uptake land and profession as rural out-migration persists (Kizos et al., 2010).

2.2 Overview of methodological approach

The development of an ABM illustrating how the farming community of Gera manages the landscape, now and in the future in the context of macro and micro level changes, adopted a participatory and iterative methodological framework summarized in a 5-step process (**Figure 1**), which is elaborated stepwise in sections 2.3 – 2.8.

- (1) Farmer interviews were undertaken with the aim of constructing a farmer typology, delineating differing land-based decision-making pathways and informing scenario development (section 2.3.1)
- (2) Based on the survey data and spatial data (section 2.3.2), an initial model was constructed (sections 2.4 – 2.6)
- (3) The initial model was presented in a workshop (section 2.7). Concepts, processes and results of the model under each of the different scenario storylines were discussed with both scientific experts in cultural landscapes research and members of the local farming community with the aim of gathering feedback for subsequent model improvement.
- (4) Feedback from the workshop was integrated in a refined model followed by a sensitivity analysis (section 2.8)
- (5) Output spatial datasets and the ABM will be made publicly available upon acceptance of the paper (see corresponding author's departmental and/or funding project webpages)

Past research has similarly involved a participatory and iterative ABM development approach, however the participatory component is at times aimed at discussing one aspect of model development only, primarily focusing on either scenario development, identification of local problematics or the discussion of interventions to previously identified problematics (Sylvestre et al., 2013). This study conducted a workshop aimed at addressing four different core aspects of ABM from which to base model refinement: structural processes of model, scenario building, model calibration and visualization of outputs. Such an approach was preferred as it enabled workshop participants to interpret the model as an object open to critique in all of its constituting aspects, thus increasing its validity and salience.

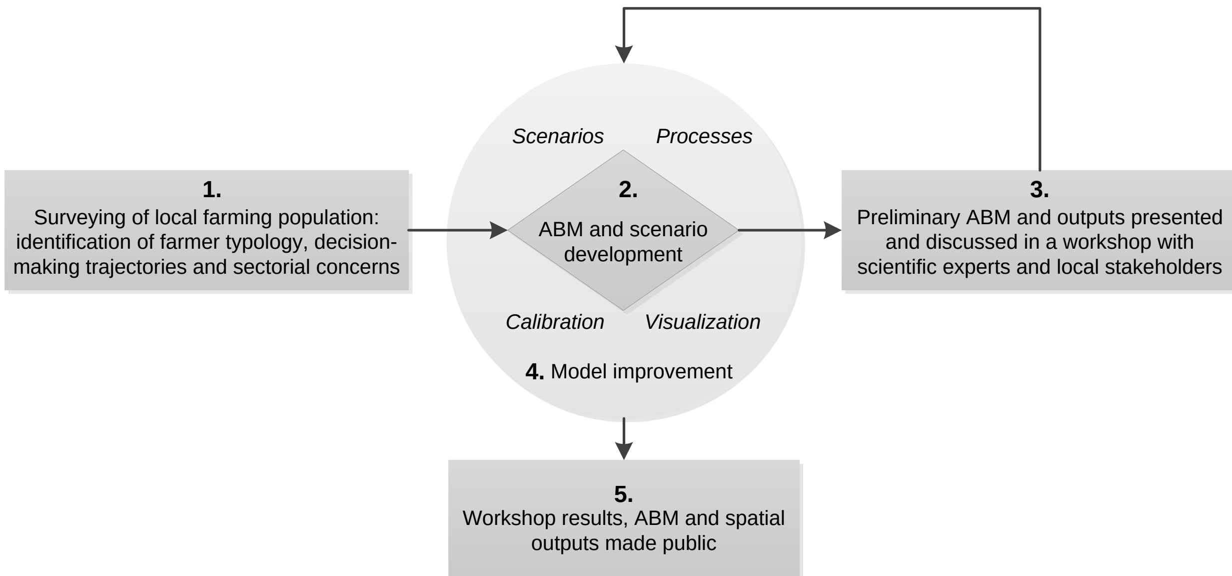


Figure 1 - The methodological framework adopted, iterative model development in consultation with local stakeholders and scientific expert communities

2.3 Surveying and spatial data

2.3.1 Farmer interviews

Interviews with 100 members of the local farming community were undertaken between June and September 2015 aimed at the characterization of the farming community and elicitation of future perspectives. The first aim was to use the interviews for the construction of a farmer typology, a widely used approach within ABM (Smajgl et al., 2011) providing type-based probabilities of occurrence for a set of attributes (**Table 1**). This effort was undertaken via hierarchical cluster analysis (see Zagaria et al., 2018) and revealed three farmer types, notably active part-timers, professionals and detached farmers (described in **Table 2**). As a second objective, the interviews were used to elicit the future perspectives of the farmers. The interviews revealed nearly 70% of farmers interviewed could expect disinvestments within the coming decade. This action was most widely foreseen by the active part-timer type despite their reliance upon alternative sources of income, emphasizing the importance of sectorial profitability. A similarly large share of farmers expressed continuing with the current farming system as the most viable course of action, while participation in social cooperatives as well as in agricultural trainings remains limited.

Table 1 - Overview of farmer agent attributes whose values were set empirically according to their probability of occurrence within the constructed farmer typology

Attribute	Description	Value measure
Farmer type	A farmer belongs to one of three types (active part-timer, detached farmer or professional); typology created by means of cluster analysis from interviews with a sample of the local farming community.	1 = Active part-timer 2 = Detached 3 = Professional
Culturally driven	The farmer has inherited land, expressed a desire to maintain it in the family and a refusal to sell	Y / N
Imitator	The farmer bases farmland decisions on the experiences of their neighbors	Y / N
Social cooperative member	The farmer is a member of an existing social cooperative; these farmers represent the initial adherent farmers to ILIs if activated in model run	Y / N

Higher level of schooling	The farmer has obtained high school level education	Y / N
Makes use of consultancies	The farmer makes use of external sources of information when making decisions on his farming system (cooperatives, formal consultancies, research organizations, internet sources)	Y / N
Has successor	The farmer has a willing successor	Y / N
Hires labor	The farmer hires labor	Y / N
Age: 18 – 34 years	The farmer belongs to the young age group	Y / N
Age: 35 – 49 years	The farmer belongs to the younger middle-aged group	Y / N
Age: 50 – 64 years	The farmer belongs to the older middle-aged group	Y / N
Age: > 64 years	The farmer is at or above retirement age	Y / N
Management intensity	Intensity with which the farmer manages the farm, assumed to be equal amongst all plots. This composite indicator is a measure of family labor, use of fertilizers, pesticides or herbicides, pruning intensity, stone wall/terrace maintenance, mechanization, tree density and irrigation. Within the context of this case study, a transition to higher intensity classes is considered a case of *sustainable* intensification.	1 = Low intensity 2 = Medium intensity 3 = High intensity
Number of plots	Number of plots belonging to a farmer	1 – 11
Farm size	Total farm size (sum of all plots owned by the farmer)	0.1 – 20 ha

Table 2 – Defining attributes of the three constructed farmer types listed alongside the (%) distribution of farmers across the typology, as identified empirically in the surveys (see Zagaria et al., 2018)

Farmer type	**Active part-timers** (27%)	**Professional farmers** (24%)	**Detached farmers** (49%)
Defining attributes	Culturally driven	Culturally driven	Lowest share of culturally driven farmers
	Extensive agricultural knowledge	Extensive agricultural knowledge	Low formal agricultural training
	Makes use of external sources of knowledge (consultations)	Makes use of external sources of knowledge (consultations)	Low use of external sources of knowledge (consultations)
	Significant non-agricultural incomes	Full-time farmers	Mix of full-time and part-time farmers
	High level of schooling	High level of schooling	High level of schooling mostly not obtained
	Low-intensity farming	Large and intensively managed farms	Low-intensity farming
	Mixed age group	Highest share of farmers in younger age groups	Dominated by ageing farmers
	Believe the future agrarian sector will be reliant upon pluri-active farmers	Fewest share of pessimists regarding the future agrarian sector	Largest share of pessimists regarding the future agrarian local sector
	Few are social cooperative members	Highest share of social cooperative members	Lowest share of social cooperative members

2.3.2 Derivation of spatial datasets

Farmer interviews informed local spatial dynamics by the recorded location of farming plots belonging to the interviewees. The importance of accessibility of farming plots was emphasized, as farmers stated de-intensification and abandonment to be more likely in poorly accessible locations. A plot accessibility layer was created, defined by plot proximity to the road network, for use within the model as a proxy for the computation of a farmer's annual transport costs. The accessibility map was included in a land suitability layer used for plot selection during the model's computation of annual land transactions. The suitability layer was generated by means of random forest regression (details in Supplementary Materials) making use of the recorded plot locations and additional independent variables, notably: aspect, elevation, slope, geology, visibility, distance to the sea, distance to the road network (accessibility) and distance to settlements. These variables were identified as influential determinants to land suitability (or value) by both experts in local landscape change dynamics and interview data.

The distribution of farmer plots belonging to the interviewed sample across the land suitability layer was used in the creation of a cadastral data layer. The total farming population was set to 1500 according to 2011 census data (ELSTAT, 2011), while the distribution of farmers over the types and the number of plots per farm were set according to the farmer survey (details in the Supplementary Materials). Plot size distribution at initiation was designed to mirror the plot size *ratios* identified between farmer types within the interviewed sample, whereby professional farmers own plots on average larger than the remainder two farmer types, and active part-timers the smallest.

2.4 Model design

The model is built upon an understanding that dynamics surrounding agricultural abandonment in the heritage olive-dominated landscapes of Gera are subject to complexity stemming from interactions between the natural environment and decision-making. This study specifically addresses aggregate complexity emerging from interactions of system components at the micro-level (Janssen, 2003; Manson, 2005; Verburg, 2006). To achieve the exploration of such dynamics, we conceptually framed the system as being dependent on one of two constituting entities: (1) farmer agents, i.e. decision makers defined by behavioral attributes, and (2) multi-level drivers, based on the premise that their aggregate behavior and interactions determine landscape and demographic transitions.

2.4.1 Behavioral attributes of farmer agents

It was assumed that actors are heterogeneous in their behavioral attributes, hereby differentiated between managerial strategy (farming intensity) and three decision-making components (goals, past experiences and interactions). These attributes are thus incorporated within the model in the attributes of the farmer agents, defined and operating as follows:

- *Goals* differ in nature and are represented in the model by a farmer having either a cultural or a non-cultural drive. The model assumes all farmers seek to maximize their annual revenues by purchasing the most productive land plots (if opting to buy). However, culturally driven farmers, unlike non-culturally driven farmers, refuse to sell their land if opting to scale-down and abandon instead, thus disregarding potential financial gains in this decision-making aspect. Farmers are considered boundedly rational as full optimization of their goals rarely occurs. This is a result of an agents' limited cognition and information, more accurately representing the more partial strategies occurring in the area (Manson, 2006; Parker et al., 2003).
- Agricultural knowledge was not explicitly modelled as an agent attribute but was instead assumed to be dependent on the farmer's behavioral attributes, notably *past experiences* and *interactions*, the latter modelled within a farmer's imitation and external consultation strategies. Imitating farmers are assumed to undertake more interaction with other agents than non-imitating farmers, thus increasing their knowledge base. Because of farmers owning plots scattered across the region, imitation does not depend on interactions with neighbors but rather with the predominant farmer type in the region that given year. Interactions are not explicitly simulated but instead assumed to shape the imitating farmers' decision-making regarding land-system change (whether scale or intensity based) and their decision to adhere to ILIs by altering the farmer's subjective norms. Subjective norms (alongside a farmer's attitude and perceived behavioral control) shape

the diffusion of ILIs utilizing concepts from the Theory of Planned Behavior, similarly modelled by Kaufmann et al. (2009) in the exploration of diffusion of organic farming practices by means of ABM; subjective norms illustrate the influential and "perceived level of approval or disapproval by important others". Consulting farmers are similarly assumed to have access to additional knowledge sources; the model thus sees consulting farmers having a higher probability to adhere to ILIs because of altered perceived behavioral control, representing a farmer's ability to perform a certain behavior. Interaction is furthermore indirectly occurring because of changes to a finite/closed decision-space within which agents operate; as farmers buy land they limit the amount of available land resources for other buying farmers.

- All farmers account for *past experiences*, hereby by favoring actions they have already experienced (see also Valbuena et al. (2010)).
- A farmer's *management strategy* represents the intensity of farm inputs used, inclusive of hired labor. Farmer interviews revealed significantly higher intensity levels among professional farmers and social cooperative members. In the model, when farmers join ILIs or switch to a professional type, they thus alter their management behavior to higher intensity. Switching to higher annual intensity levels assumes higher yields but also higher annual costs to farmers.

2.4.2 Decision-making and behavioral transformations

The behavioral attributes listed above, alongside non-behavioral attributes of farmers (e.g. age, level of schooling) inform the three different types of decisions faced by farmers in a yearly model run, notably: (1) land-based decisions (related to scale enlargement or shrinking only), (2) adherence to ILIs and (3) type-switches (related to intensification or de-intensification of the land system). A decision to expand a farming system relates directly to behavioral attributes of past experiences and inter-agent interaction, as farmers are assumed path-dependent and more likely to expand if imitators and in a context of prevailing professionalism. Age additionally influences a probability to expand, as younger farmers are more likely to do so (widely expressed as an influential factor throughout the stakeholder workshop (Section 3.1), in part related to more opportunities in terms of subsidies and other financial supporting schemes). Additionally to these factors, decisions regarding shrinking of farm are dependent upon a farmer's cultural drive (goals), but also their past profits or lack-thereof and level of schooling. The same decision-making process is run for cultural and non-cultural farmers. Younger farmers with a higher level of schooling having witnessed declining profits are assumed as more likely to opt for shrinking of system as part of a transition to alternative employment (see also Acosta et al. (2014)); farmers having recently witnessed increasing profits do not consider scaling down. **Figure 2** illustrates how these specific attributes hold equal weight in determining the probability of a farmer undertaking each of these actions. The final probability value to sell is set to always be higher than that to abandon, as abandonment is assumed as a more reluctant decision taken by farmers.

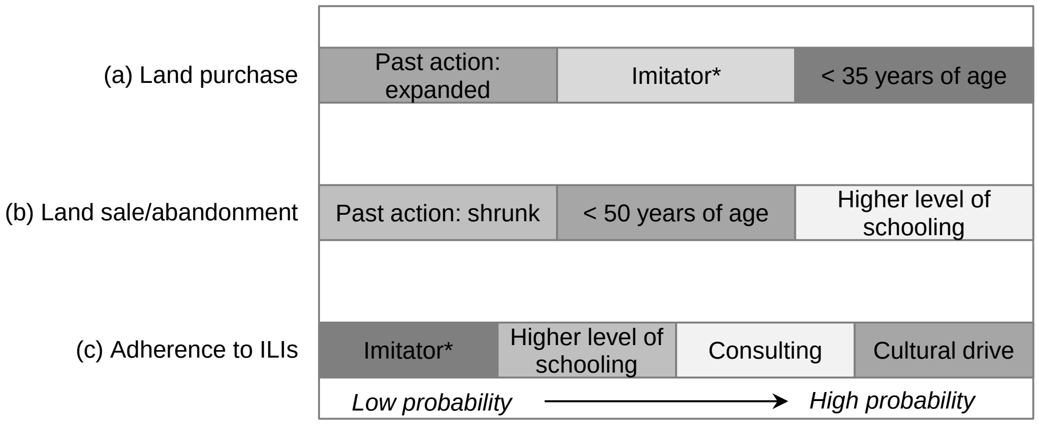


Figure 2 – Establishing probabilities for farmer decision-making regarding (a) expansion or (b) shrinking of farming system and (c) adherence to ILIs. The occurrence of each listed farmer attribute increases the probability of the decision taking place by an equal amount. *In a prevailing professional farmer type context, imitating farmers favor purchase of land. In a year where detached or active part-timers are the prevalent type, an imitator attribute disfavors purchase while a non-imitator attribute would encourage it. Regarding adherence to ILIs, imitating farmers have a higher probability of adherence.

Behavior is considered an evolving and changing process culminating in behavioral transformations hereby represented by farmers undergoing type-switches. Decisions to undergo a type-switch are in part dependent on past-actions and profits. If a farmer is making losses, they may consider de-intensification as opposed to scaling down, switching to active part-timer or detached farmer types. On the other hand, if a farmer has accrued or lost enough land through time, they will alter their management strategy in response and undergo a type-switch. A farmer's cultural drive is additionally assumed to influence type-switches, as culturally driven farmers are more likely to transition away from the detached type. Type-switches are age dependent under the assumption that farmers above retirement age will not undergo type-switches unless they are professional farmers, in which case they will switch to the active part-timer type. The probability of a farmer undergoing a type-switch is dependent upon all of the dependent attributes occurring, thus differing from decisions illustrated in **Figure 2** whose probabilities are determined based on the summated occurrence of attributes.

Figure 3(a) illustrates the immediate feedbacks surrounding such behavioral transformations. Undergoing a type-switch only alters a farmer's behavioral management strategy, not affecting the decision-making attributes of behavior of the farmer. Key to understanding the implications of such a transformation is the consideration of successors and inheritance of attributes (**Figure 3(b)**). Successor farmers do not inherit but reconsider their goals, or cultural motives, depending on their inherited type. The model thus allows for an investigation of changing behavior past the present generation of farmers. Joining ILIs influences both aspects of behavior, driving farmers towards more culturally oriented goals and promoting interactions for knowledge transfer. By directly influencing the decision-making attributes of agent behavior, adhering to ILIs thus enhances likelihood of undergoing a type-switch (**Figure 3(a)**).

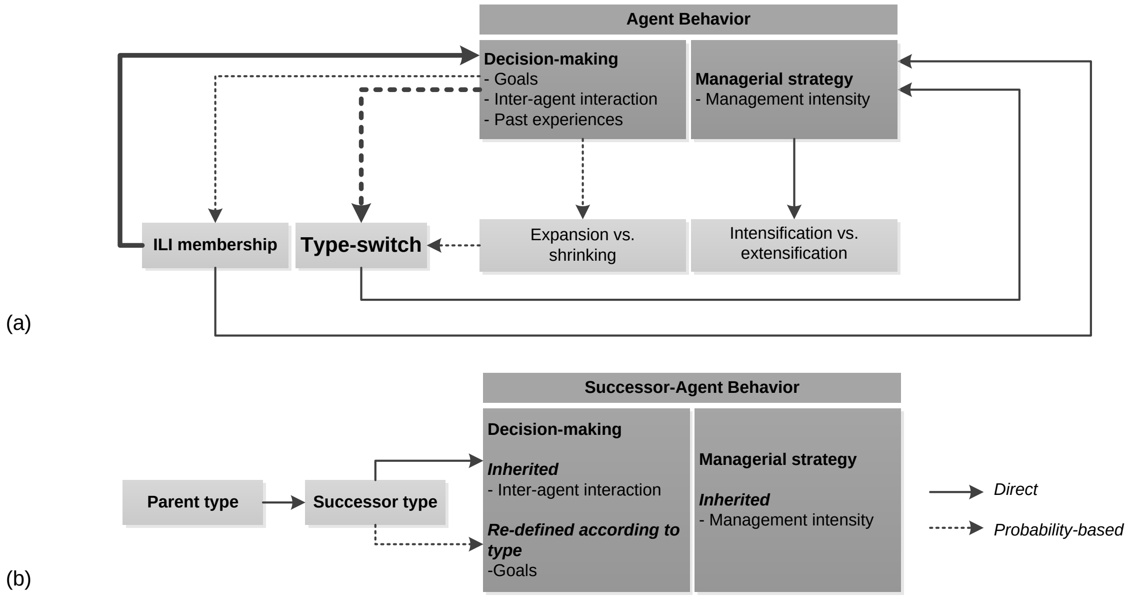


Figure 3 - (a) Feedbacks between type-switches, ILI membership and behavioral attributes and consequential effects on landscape change; emphasis is placed on the role of ILIs in altering decision-making attributes and enhancing behavioral transformations via type-switches (b) Inherited and re-defined behavioral attributes of successor farmers to be considered in the understanding of implications of behavioral transformations for the coming generation of farmers

2.4.3 Landscape change

The actor dynamics and interactions hold varying implications for landscape change. Changes in management strategy imply a direct intensification or de-intensification of the current farming system. This changes a farmer's annual costs and thus may additionally influence scale-based decision-making in subsequent time steps. A single plot is assigned to a decision regarding the purchase or selling/abandonment of land, selected according to whether it has the highest or lowest land suitability value respectively. Following a period of abandonment of 5 years, fields witness a land-cover transition to wooded grassland and shrub, after an additional period of abandonment of 15 years the fields are considered forested (Koulouri and Giourga, 2007). As land undergoes land-cover changes to shrub or forest the land suitability value of land decreases, in turn decreasing the likelihood of abandoned fields being purchased. If a farmer buys a plot that was previously abandoned, the farmer undergoes a one-off land conversion cost and the plot increases in land suitability value.

2.4.4 Multi-level drivers

The drivers of change incorporated within the model are "multi-level" or multi-scale, as they account for external drivers and locally-based ILIs. Macro drivers of change are based on de Graaff, Duran Zuazo, Jones, & Fleskens (2008), having modeled sloping and mountainous olive production systems of the Mediterranean under a range of socio-economic development scenarios. Their study determined five main influential factors to the future development of olive production systems, notably climatic variability, reduced accessibility, demographic changes, policies and market prices of olive oil. Their model ultimately excluded climatic variability and reflected accessibility and demographic changes within labor wage rates. Our study similarly excluded both variables in an attempt to narrow scope and complexity of model following workshop insights (see Section 3.1). We adopted two of the four scenario storylines developed by de Graaff et al. (2008), notably the "Bright" and "Doom" scenarios simulating contrasting changes to subsidies, wage rates and olive oil prices, mirroring the concerns identified in our case study area closely linking sectorial profitability and availability of labor to the maintained cultivation of olive plantations. These drivers influence the costs and profits gained by farmers throughout their yearly wealth computation, and thus represent the profitability of the sector.

ILIs were not modelled as separate entities but rather manifested themselves by directly inducing changes to the behavioral attributes of adherent farmers. Starting membership to ILIs and type-based probabilities of farmers being adherent members were based on farmer interviews investigating whether farmers were members of presently existing social cooperatives (and thus more prominent amongst professional farmers). Like a farmer's cultural motivations, membership to ILIs is re-considered by successor farmers and not an inherited attribute. If ILIs are activated in the model run, each farmer that is not already a member will consider joining. Their diffusion is enhanced by imitating farmers responding to an increasing portion of farmers in the region having already adhered to the initiatives, the inquiring farmer's cultural drive, schooling level and use of external consultations (see Section 2.4.1). Joining an ILI in turn increases a farmer's management intensity to the highest level (assuming sustainable intensification), potentially changes a farmer's motivational values from non-cultural to cultural, introduces the farmer to external consultancies and increases the probability that the farmer will have a willing successor (supporting literature in García-Martín et al. (2016); Sottomayor, Tranter, & Leonardo Costa (2011)).

2.5 Model implementation

An outline of model processes undertaken in each yearly run is illustrated in **Figure 4**, furthermore presenting points of influence of ILIs and macro-level drivers. The model was developed in the open source environment NetLogo version 5.3.1 (Wilensky, 1999), making use of the GIS extension. The processes outlined are those set in place following a model refinement phase informed by a workshop with experts in cultural landscape change and members of the local farming community (Section 2.7). A comprehensive overview according to the Overview, Design Concepts, Details + Decisions Protocol (Grimm et al., 2010; Müller et al., 2013) and list of attributes of the model's entities are outlined in the Supplementary Materials.

2.6 Scenarios

This study draws conclusions based on the results of four simulations; the outcomes of Doom and Bright scenarios are evaluated individually with and without the consideration of ILIs. The contrasting annual rates of change in olive oil prices, labor wages and subsidy support under Bright and Doom scenarios are outlined in **Table 3**.

Table 3 – Macro drivers of change under the two contrasting "Bright" and "Doom" scenario storylines; values represent annual rates of change (%)

	Annual rates of change (%)		**Change over simulation period of 25 years**	
Attribute	**Bright**	**Doom**	**Bright**	**Doom**
Olive oil prices	2	0	50% increase	No change
Labor wages	0	2	No change	50% increase
Subsidies	1	-4	25% increase	Phased-out entirely

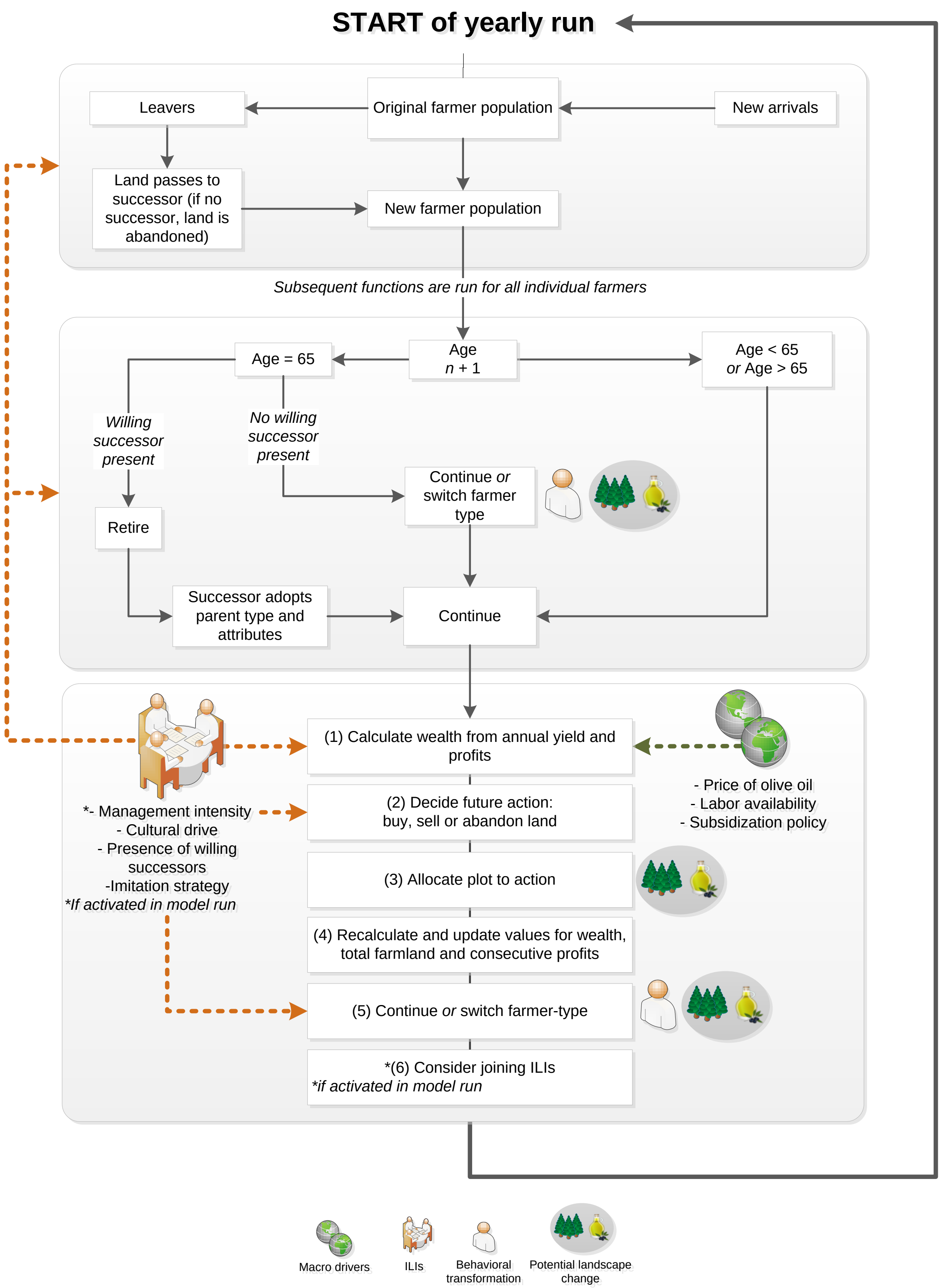


Figure 4 – Overview of yearly model run, outlining points of influence of changing macro drivers and implemented ILIs

2.7 Stakeholder workshop: model validation and refinement

A workshop was held with cultural landscape experts and members of the local farming community to validate and refine the preliminary model. 38 people participated in the workshop: 23 cultural landscape experts and 15 representatives of the local farming sector. The workshop took place on April 21, 2016 in Pappados and lasted 2 hours, making use of breakout groups, individual anonymous questionnaires and open discussions. This diversity in eliciting approaches was adopted to maximize input from participants.

The workshop began with an explanation of the model and its development process, elaborating on input data sources and outlining the procedures resulting in diverging scenarios (notably: conservation of the traditional landscape, agricultural liberalization and Business as Usual trajectories). The researchers stressed the model was a tool that, despite having a strong empirical component, necessitated additional critical insight from both the local farming and external cultural landscape experts, asking the participants for their help in improving the ABM by discussing (1) its modelled procedures, (2) scenarios, (3) the magnitude of driving and non-driving variables and (4) the visualization of outputs.

Local community members were split into three groups each discussing one of the three modelled scenarios, while cultural landscape experts brainstormed and discussed all scenarios as a group. The groups were presented with their respective scenario for discussion on an A2 poster and handouts illustrating demographic and landscape changes and were handed pens and post its with which to transcribe their feedback. The two communities were subsequently asked to fill in separate questionnaires (in Supplementary Materials). These aimed to validate or challenge the modelled processes and concepts using Likert scale and weighting questions on model parameters while also including a feedback section on the workshop process. An open discussion amongst local community members followed, addressing future challenges and opportunities associated with the local agricultural sector.

Following Johnson (2015), the workshop aimed to address many drivers of change, while understanding that their inclusion within a “final” model may not be desirable or possible. This approach was favored as to focus discussion on challenging model assumptions and to avoid misrepresentations or misunderstandings in the final outputs. Therefore, the scenarios presented in the workshop differed from those outlined in Section 2.4.4/2.6, primarily by presenting causal relationships and feedbacks between ILIs and macro-level drivers. Workshop findings resulted in alterations to a final model following a similar iterative process of qualitative evidence gathering and analysis as that undertaken by Polhill, Sutherland, & Gotts (2010); the results thus present summarized (primarily qualitative) evidence from the workshop, illustrating how and why findings were or were not integrated within a refined model.

2.8 Sensitivity analysis

As the model includes stochastic processes it was necessary to establish a number of replications from which to average model output results. Using baseline values for all variables, the coefficient of variation was calculated for 13 model output variables, under each scenario, for 30 runs, following the approach set out by Lorscheid, Heine, & Meyer (2012). This led to the selection of 20 iterations for determining final average-based output values. Sensitivity analysis was subsequently undertaken using a one parameter at a time (OAT) analysis. Despite the limitations of this method (most importantly related to not accounting for implications of simultaneous alteration of multiple parameters) this approach was deemed appropriate due to its simplicity providing sufficient and fast insight as well as enhanced communication potential.

Similarly to Schouten, Verwaart, & Heijman (2014), minimal and maximal value ranges to the variables altered by sensitivity analysis were set around the pre-defined base value to evaluate as part of the sensitivity analysis. Description of the analysis process, variables used and value ranges tested are found in the Supplementary Materials. Model sensitivity to the parameters altered by macro conditions or ILI implementation was not assessed by testing maximum and minimum value ranges as these parameters were either binary or set upon specific values whose alteration would not be possible, as it would disrupt modelled processes dependent upon specific ratios related to these parameters. Their analysis was therefore undertaken by running the model with and without any change occurring to each of these parameters individually.

3 Results

3.1 The stakeholder workshop

3.1.1 Feedback on model structure and validity

Feedback and discussion with the local farming community largely confirmed the processes integrated within the preliminary model. Discussions showed agreement with the farmer typology and the variables used for mapping land suitability. Farmers re-instated the critical role field accessibility plays in abandonment. These participants stressed the importance of sector profitability for sustaining agriculture and heritage in the future ("[economic] motivation is needed so that the number of producers will increase and become more active") and they agreed a scenario portraying gradual removal in subsidy support is likely to result in increased abandonment trends. There was general consensus on the importance of current olive oil prices ("the price of olive oil is low at the moment, meaning no profits, no labor hiring and no development"), which was also deemed the most influential factor in the emergence or success of ILIs while subsidies were deemed least influential (**Table 4**).

Management intensity was confirmed as the most influential factor in determining yields; age and external consultations were seen as key attributes for scale expansion and age and level of schooling for decisions to scale down. The low number of participants not giving a weight or providing an "other" variable in the weighing exercises indicate the variables identified by the researchers to represent decision-making processes in the preliminary model are largely representative (**Table 4**). Estimates on the number of newcomer farmers and proportion of farmers to join ILIs did not reveal significant trends. The cultural landscape experts characterized ILIs as influential to societal change, drawing upon concepts of existing community networks and knowledge transfer and exchange. The importance of sectorial cooperation was stressed in the mentioning of a necessity for better legislative frameworks, political support, subsidized local markets and development of tourism.

Table 4 – Average weight scores attributed to influential factors comprising modelled processes by the local community in the weighting exercise of the questionnaire. Also stated are the average number of "other" factors and NA scores provided by respondents per weighting exercise

Model process	Influential factors Highly rated	Average score	Lowly rated	Average score
Emergence/success of ILIS	Price of olive oil	4.6 / 5	Subsidies	2.8 / 5
	Accessibility	4.0 / 5	Labor wages	3.1 / 5
Annual yield	Management intensity	2.8 / 3	Slope	2.1 / 3
Scale expansion	Age	2.6 / 3	Past actions	2.2 / 3
	Use of external	2.6 / 3		

	consultations			
Scale decline	Age	3.6 / 4	Past actions	2.7 / 4
	Education	3.3 / 4	Cultural drive	3.0 / 4
	“Other” answers provided per weighting exercise	1 / 14	**NA scores provided to variables per weighting exercise**	4 / 14

Break-out groups discussed existing nuances to the more straightforward causal relationships present in the preliminary model. **Table 5** presents a summary of the feedback obtained on the preliminary model presented. Half of the cultural landscape expert community was “unsure” the macro-level drivers specified (subsidies, olive oil prices, land availability and accessibility of plots) would determine the emergence or success of ILIs in the region, stating that while the mentioned drivers were important, they represented a predominantly economic, rather than cultural or comprehensive, perspective. Similarly, 47% disagreed ILIs would not emerge in a scenario illustrating agricultural liberalization; a lack of political willingness and action to tackle local abandonment could “push” the emergence of grassroots initiatives to address these issues. This led to the alteration of scenario storylines within the refined model version, whereby ILIs are not seen as emergent to a set of conditions but are imposed by the modelers in different simulations.

Additional statements expressed by both communities supported post-workshop model alteration to two contrasting scenarios. Locals did not see the continuation of current trends in a “Business as Usual” scenario as realistic as the present situation is largely deemed unsustainable. They stated “no-one can buy land these days”, “due to economic crisis, farmers get the most of their available land” and “most farmers of the region cannot afford investments”. Locals additionally felt the scenarios resulted in unexpectedly insufficient diversity in landscape change. An absence of middle grounds was palpable also in the final open discussion. While some members of the local farming community advocated for stronger mobilization for heritage protection and conservation, making use of tourism resources, other farmers opposed this view and called for re-grounding focus on enhancing productivity of olive plantations as this is the only way to secure profits to the sector (**Table 5**).

Uncertainty was expressed by local participants regarding outcomes of potential feedbacks and interactions amongst the drivers. For example, participants suggested a collapse of subsidies could lead to widespread abandonment but may also feedback to new farmers because of higher land availability. Other participants stated they expected further declines in olive oil prices from the involvement of countries with lower labor wages in the market, yet recognized this was unpredictable as dependent on migration fluxes. While this exemplifies the ease and accuracy with which workshop participants grasped the ABM processes and are aware of the multi-faceted complexities inherent to local landscape change, such feedbacks were not integrated in a refined model to refrain from reaching a level of complexity undesirable within ABMs and paradoxically introducing further uncertainty via the assumptive creation of additional causal relationships (Axelrod, 1997; Le et al., 2012).

Table 5 - Synthesis of statements by cultural landscape experts (C) and local farming communities (L) that either explicitly stated feedback on model improvement or elicited model improvement while emerging from wider discussions about present sectorial concerns throughout the workshop. Rationale behind choice of integration or non-integration in a refined model is specified for each statement.

Core aspects of ABM	Statements (C = cultural landscape experts, L = local community)	Integrated?	Modification	Rationale
Processes	(L) Divergent views: plot sale or purchase based solely upon land suitability vs. emotional attachments to plots irrespective of their suitability values	N	-	Low profitability of sector identified as a limiting factor for all farmer types, translated to all farmers choosing to maintain or purchase most productive plots; difficulty of linking emotional bonds with specific plots to spatial attributes
	(L) Processes of climate change, political instability and financial crisis would alter the modelled process by increased desertification, spread of disease, changes to taxes, agricultural reforms and tourism influences	N	-	Lack of data; increased complexity beyond scope of model
	(C) Additional factors are important and may alter the model processes: gender roles, the wider job and housing markets, climate change, energy availability and price, migration, subsidized agricultural technologies	N	-	Lack of data; increased complexity beyond scope of model
	(L) Additional feedbacks are important and may alter the model processes: more land availability, altered wages from new, competitive markets	N	-	Lack of data; increased complexity beyond scope of model
	(L & P) Purchase of abandoned plots is possible but difficult and requiring high costs to purchasing farmers	Y	Rendered abandoned plots available for sale in all scenarios. Included conversion costs to farmers purchasing previously abandoned plots	More accurate representation of occurring processes to increase validity of model
	(L) Road construction is very difficult in the region	Y	Changes to road network and plot accessibility do not occur under any scenario	Limit amount of macro drivers, translate changes to accessibility and demographics to wage rates only; closer alignment with de Graaff et al. (2008); limit complexity
	(C) Links between state of macro drivers and emergence of ILIs cannot be assumed linearly	Y	Macro drivers and ILIs are decoupled; ILIs are not seen as emergent but imposed under two contrasting scenarios with divergent properties of macro drivers	Assumption of direct causal linkages between ILIs and macro drivers rejected by participants at workshop; limit complexity; allow for a more direct comparison of the effects of the two drivers
Calibration	(L) Other strategies identified: use of non-native olive varieties and sale of olive tree wood to guarantee small but safe profit	N	-	Lack of data; increased complexity beyond scope of model
	(L) Young people reluctant to get involved in sector	Y	Introduced new generation as an attribute and monitor plot in the model interface; calibration of probability of succession	Allow for assessment of landscape and behavioral transformations beyond the present generation of farmers; provide an analysis of generational change; more accurate representation of occurring processes to increase validity of model
	(L) At present very few farmers are buying or are able to make investments of any kind	Y	Calibration of probability of land expansion by farmers	Increase model validity
	(L) Management intensity is the most important factor determining yield. Highest annual costs attributed to hired	Y	Weighting of yield function to account for importance of management intensity over slope	Increase model validity

	labor, lowest to transport			
	(L) Higher importance of age and education than past actions and cultural drive when choosing to scale-down; high influence of age and external consultations in comparison to past actions when expanding; high importance of olive oil prices and low influence of agricultural subsidies in the emergence of ILIs	N	-	Factors remain equally important in decision-making due to controversial use of averages for setting equal weights across a heterogeneous farming population
Scenarios	(C) Uncertainty was expressed with regards to whether the scenarios and model captured the local situation in a realistic and credible manner	Y	Two new scenarios implemented illustrating divergent properties in macro drivers	More accurate representation of occurring processes as expressed throughout workshop to increase validity of model
	(C) Alternative scenarios which would be important to consider: climate change, permanent residence of migrants, agricultural education, role of migrations in tourism industry, subsistence farming, political and financial collapse	N	-	Lack of data; increased complexity beyond scope of model
	(C) Agricultural liberalization is too ambiguous a term to be utilized as a scenario description	Y	New scenarios more abstractly titled Bright and Doom	Two deliberately diverging storylines favoring and disfavoring abandonment assume no linkages between macro drivers themselves; limit complexity
	(L) “Business as Usual” scenario not realistic, the current situation is not sustainable	Y	Removal of BAU scenario, implementation of two contrasting scenarios only	Two deliberately diverging storylines favoring and disfavoring abandonment assume no linkages between macro drivers themselves; shift focus to explore and discuss consequences of “what if’s?” and remove assumptive linkages
	(L) Scenario results not very “extreme”	Y	Two new scenarios implemented illustrating divergent properties in macro drivers	Two deliberately diverging storylines favoring and disfavoring abandonment assume no linkages between macro drivers themselves; shift focus to explore and discuss consequences of “what if’s?” and remove assumptive linkages
	(L) Divergent views: return to the more productive functions of olive cultivation vs. pursuit of heritage conservation as part of tourism-oriented initiatives	N	-	Interactions with tourism industry, both in terms of additional sources of income and land use transitions deliberately not included in model as to limit complexity by the analysis of olive-cultivation transitions only. These views are however manifested in decision-making regarding adherence to ILIs (assumed to stem from desire for heritage conservation in the cultivated olive landscape)
	(C) Incorrect to assume ILIs would not emerge in a scenario forecasting agricultural liberalization	Y	Macro drivers and ILIs are decoupled; ILIs are not seen as emergent but imposed under two contrasting scenarios with divergent properties of macro drivers	Assumption of direct causal linkages between ILIs and macro drivers rejected by participants at workshop; limit complexity; allow for comparison of two drivers
Visualization	(C) Clearer visualization of land use changes and actor types needed	Y	New maps depicting plot ownership according to the farmer typology; simplified background and land use classification	Increase readability and communication of results

3.1.2 Stakeholder evaluation of the workshop process

Over 90% of cultural landscape experts agreed the workshop allowed them to both share and acquire new knowledge and that thinking of scenarios is important for the preservation of local agricultural landscapes. The majority (69%) agreed the modeled simulations represented a helpful tool in discussing alternative futures. There was stronger consensus within the local farming community about the utility of the workshop and ease of understanding of modelled processes. Detailed results of the stakeholder evaluation are in the Supplementary Materials.

3.2 ABM simulations

All four scenarios envisage a decline in farming population numbers and increase in the extent of abandonment across Gera over the upcoming 25 years. The smallest changes occur in the Bright scenario with implementation of ILIs, illustrating a 13% decrease in farming population and abandonment of 42% of fields, a 10% increase from the estimated present extent (**Table 6**). Only the "Bright + ILIs" scenario is able to demonstrate a reversal in abandonment trends within the simulated period (**Figure 6a**), beginning 17 years into the simulation and associated with a recovery in farming population numbers (**Figure 8a**). ILI implementation under Bright conditions reduces population decline and extent of abandonment by 18% when compared to the "Bright – ILIs" scenario. While at least a stabilization of abandonment rates seems to occur within both Bright scenarios, trends under Doom conditions suggest a collapse of the farming population with and without ILI implementation; both storylines foresee a decline in farming population by 58% and abandonment extent almost reaching 80%.

In scenarios where ILIs are implemented more than 50% of farmers adhere to the initiatives irrespective of conditions in macro-drivers. ILI implementation is crucial to the intensification of the land systems and promotion of new generation farmers under both Bright and Doom conditions (increases of approximately 65 and 30% respectively, **Table 6**). The proportion of new generation farmers is equal in both Bright and Doom scenarios, despite numbers of farmers varying considerably, due to the passing of the land to new generation farmers when the present generation reaches retirement age. De-intensification is much less prevalent under all simulations, although highest in the Doom scenario without ILIs.

Table 6 – Model results illustrating the extent of landscape and demographic changes following a 25 year simulation under two contrasting Doom and Bright scenarios, with and without the implementation of ILIs. Values are averages of the final yearly time-steps from 20 complete model runs. *Starting conditions: abandoned fields (32%), ILI members (11%)

Scenario	% Change in farmer population	% New generation farmers	% ILI members*	% Abandoned fields*	De-intensified fields (% of cultivated)	Intensified fields (% of cultivated)
Bright + ILIs	-13	71	74	42	3	82
Bright - ILIs	-31	41	7	60	8	18
Doom + ILIs	-58	71	63	79	5	81
Doom - ILIs	-58	41	6	78	11	14

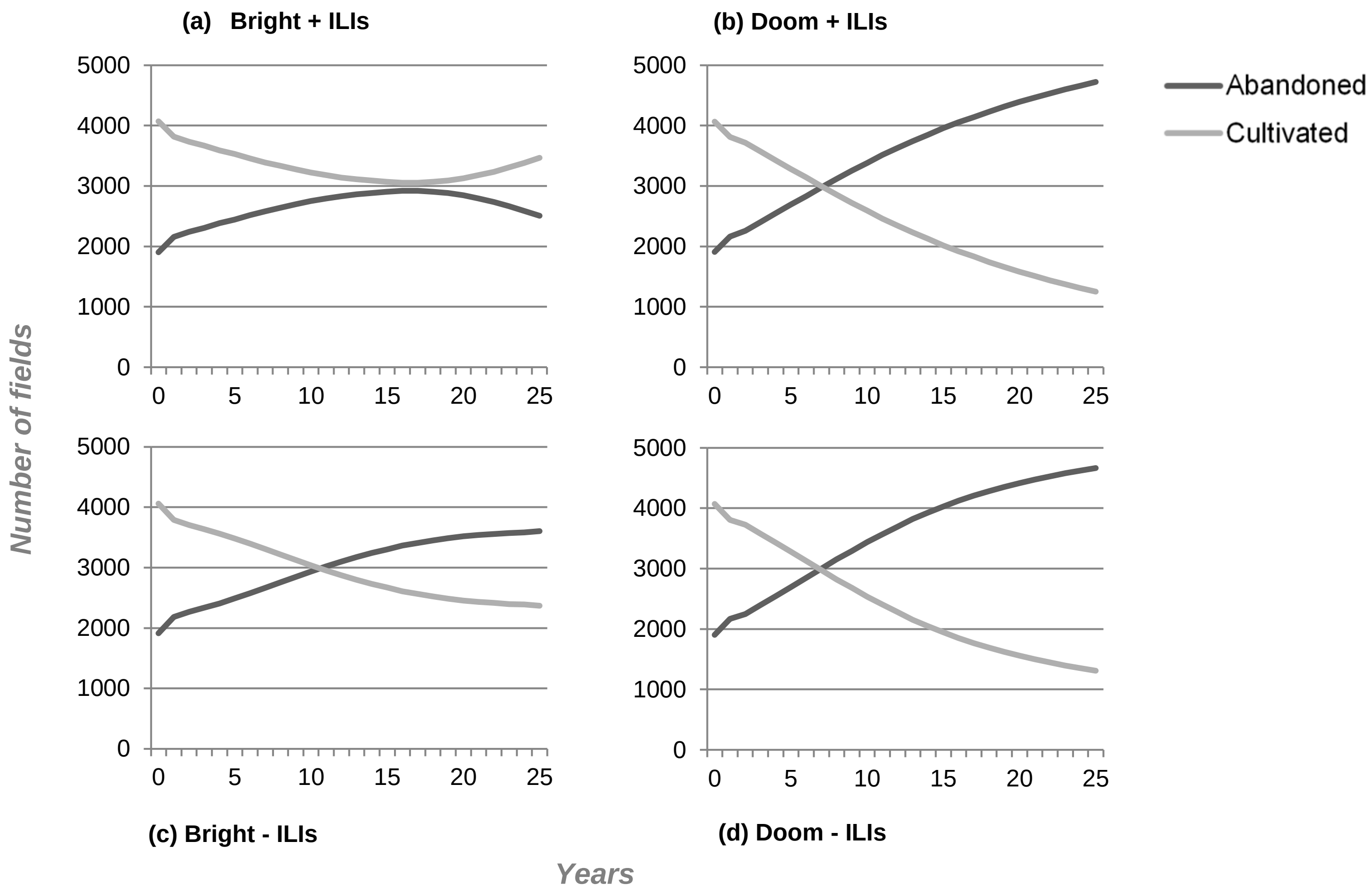


Figure 6 – Number of abandoned and cultivated fields throughout a 25 year simulation under two contrasting Doom and Bright scenarios, with and without implementation of ILIs. Values are averages from 20 complete model runs

These changes are associated with transitions occurring between the different farmer types (**Figure 8**, **Figure 9**). Favorable changes to macro drivers alone do not trigger sufficient behavioral transformations able to shift the prevalent worldview; as can be seen in the Bright (and thus more profitable) scenario with no ILIs whereby the predominant farmer remains detached. The trend is less pronounced then in the Doom scenario without ILIs, where detached farmers represent 61% of the farming population compared to 37% (**Figure 9**). Implementation of ILIs sees a shift in the predominant farmer type from detached farmer to professional irrespective of the state of macro drivers in the two scenario storylines; yet this behavioral transition does not suffice for halting the advancement of abandonment. While ILIs favor active part-timers over detached farmers under Bright conditions, the opposite is true under Doom. The Doom scenario with ILIs is the scenario that more closely resembles the present distribution of farmers across the constructed typology, enhancing the prevalence of detached farmers. The two most contrasting scenario storylines (Bright with ILIs vs. Doom without ILIs) demonstrate a polarization of professional and detached farmer types prevailing across the region.

Under all four scenario storylines the most frequent type switches occur from the active part-timer type towards the professional, while fewest occur in the opposing trend away from professionalism as seen in transitions from the professional to the active part-timer type and transitions from the active part-timer to the detached farmer type (**Figure 9**). These transitions additionally demonstrate macro-drivers hold considerable influence over sectorial professionalism, as demonstrated by the high number of active part-timers switching to the professional type or away from detachment in a Bright scenario without ILIs.

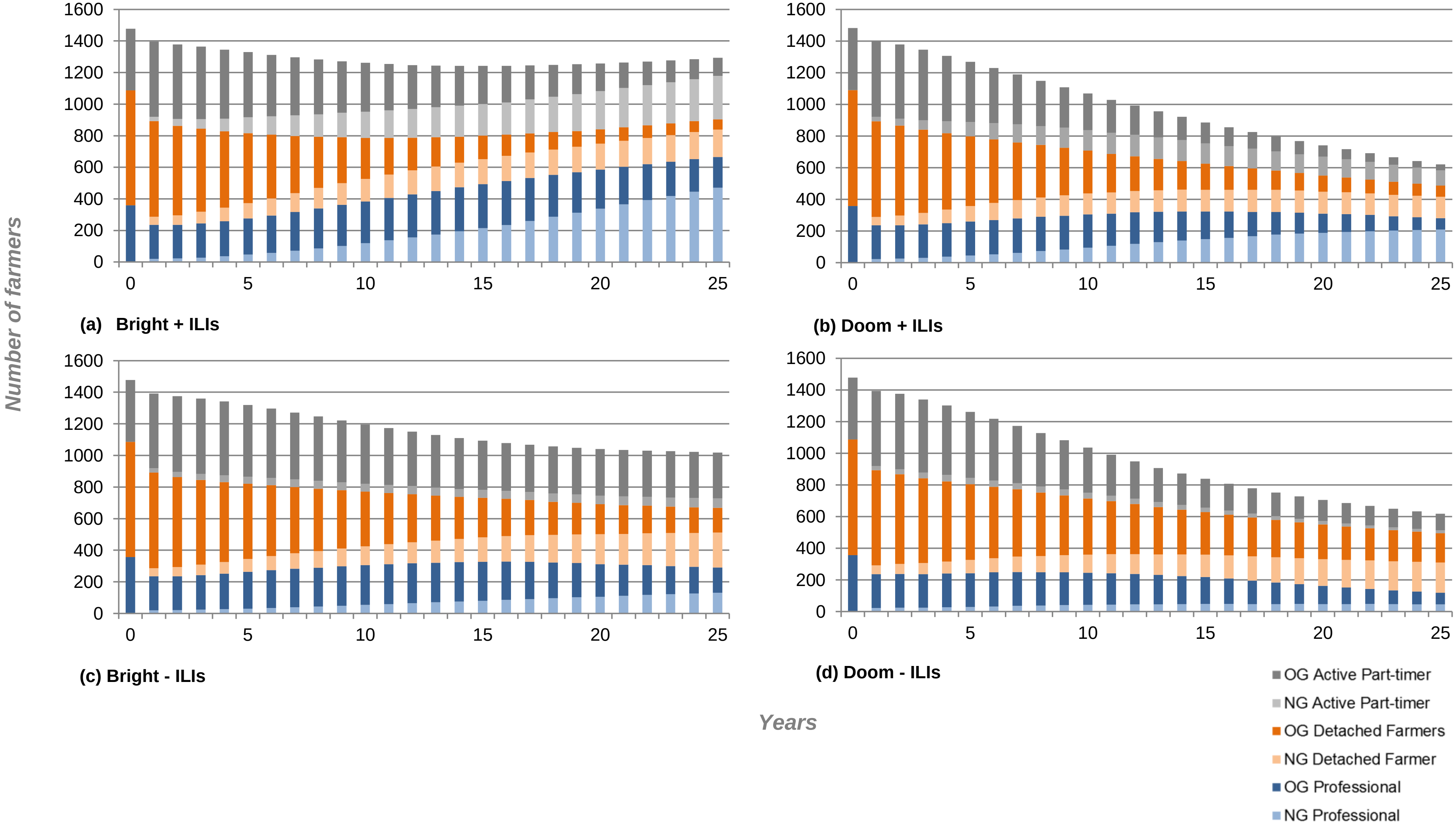


Figure 8 – Changing farmer typology composition amongst old and new generation farmers throughout a 25 year simulation under two contrasting Doom and Bright scenarios, with and without the implementation of ILIs ; NG = new generation farmer, OG = old generation farmer. Values are averages from 20 complete model runs

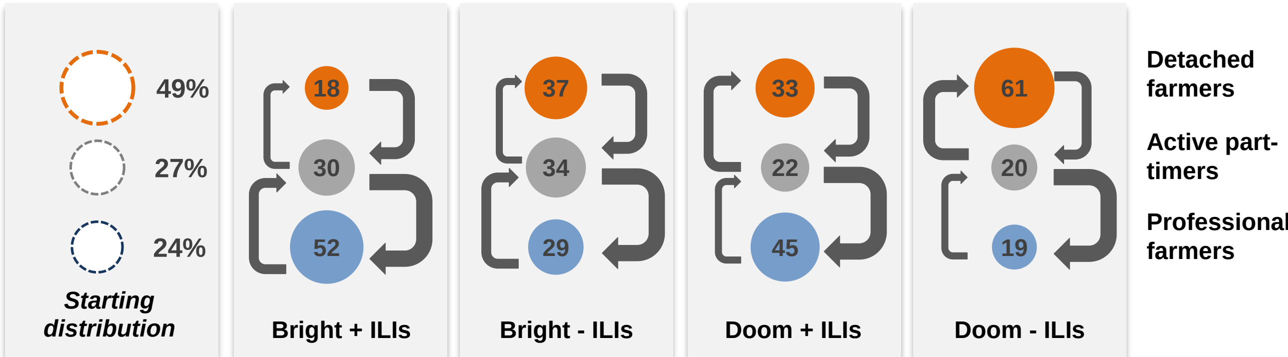
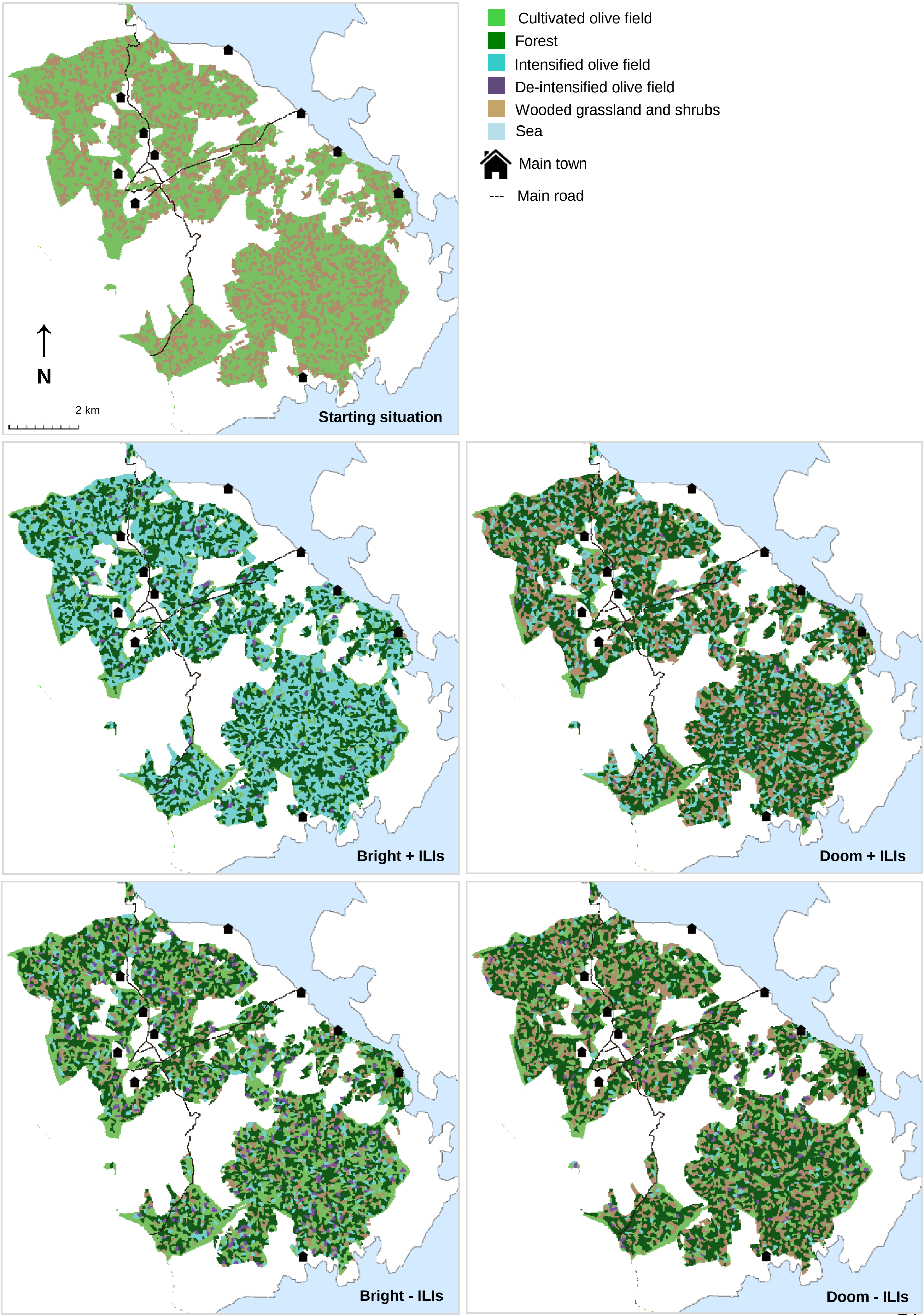


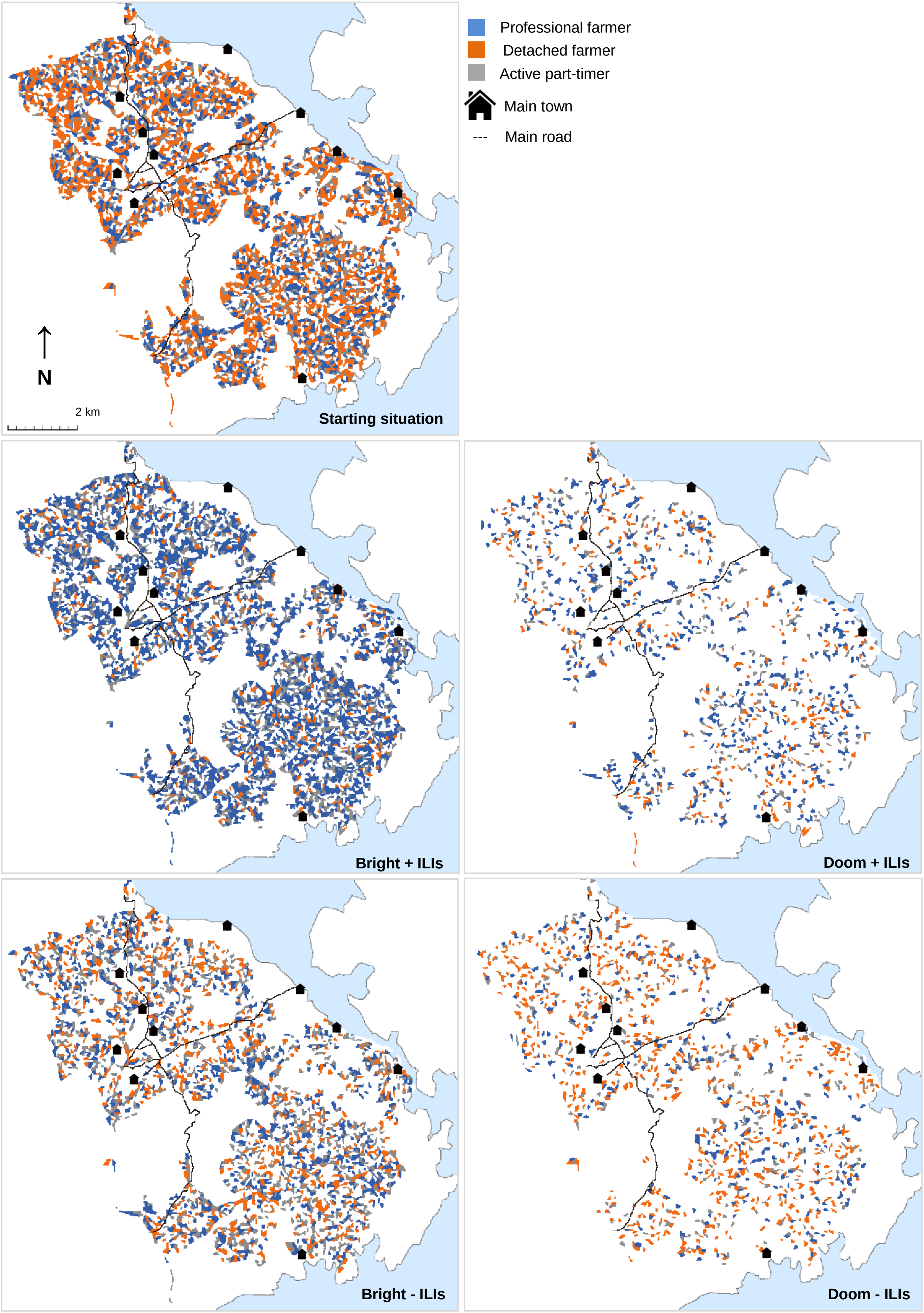
Figure 9 – % Farmer typology composition following a 25 year simulation under two contrasting Doom and Bright scenarios, with and without the implementation of ILIs. The size of the arrows represents the ordinal importance of farmer type-switches based on the number of transitions throughout the simulation period. Values are averages of the final yearly time-steps from 20 complete model runs. The starting distribution is based on the result of the cluster analysis undertaken with the interview sample.

The ABM generates output data layers illustrating the extent of land cover changes across the landscape of Gera (short and long-term abandonment, intensified and de-intensified olive cultivation) as well as changing land ownership across the farmer typology. The extent of changes to land cover and plot ownership by farmer type class under each scenario with and without implementation of ILIs are illustrated in **Figure 10** and **Figure 11** respectively. These data layers were analyzed on a pixel-basis for the identification of majority (highest frequency) areas for each relevant land cover or farmer type class in turn corresponding to pixels with lowest standard deviations (< 0.35 / 1.0) derived from a series of 20 final year output layers for each of the modelled scenarios. These "hotspot" areas were assessed against the land suitability layer for the investigation of eventual correlations while additionally providing qualitative information on the extent of uncertainty and stochasticity of the spatial model outputs.

Between 20 and 22% of cultivated land in the region of Gera at the end of each simulation was identified as a hotspot area for one of the three farmer type classes. Active part-timers had the highest percentage of hotspot areas in all scenarios except “Doom – ILIs”. Hotspot areas for the professional farmer type make up < 20% of majority areas for their type class in all simulations and were not at all identified in simulations that did not include ILIs. An analysis of how these typology hotspot areas relate to the land suitability layer reveals all farmer types see a higher average land value of plots in Doom scenarios when compared to Bright, as farmers are more inclined to shrink their farming systems in Doom conditions and keep their most valuable plots. Highest average land suitability remains with professional farmers under each of the scenario simulations.

Land cover classes found greatest locational stability amongst the iterations within the “Bright – ILIs” scenario storyline, whereby 34% of total area was identified as a hotspot location, primarily a result of the location of intensified plots (57% hotspot area). De-intensified plots conversely found greatest variability in location throughout the iterations, as no hotspot areas were identified in three of the four scenario simulations. On average, plots that underwent long-term abandonment witnessed the highest average amount of hotspot area across the four scenario simulations (26%) (see Supplementary Materials for comprehensive results).


Cultivated olive field
Forest
Intensified olive field
De-intensified olive field
Wooded grassland and shrubs
Sea
Main town
Main road
N
2 km
Starting situation
Bright + ILIs
Doom + ILIs
Bright - ILIs
Doom - ILIs



Professional farmer
Detached farmer
Active part-timer
Main town
--- Main road
N
2 km
Starting situation
Bright + ILIs
Doom + ILIs
Bright - ILIs
Doom - ILIs

Figure 10 – Land use in the olive landscape of Gera following a 25 year simulation under two contrasting Doom and Bright scenarios, with and without the implementation of ILIs

Figure 11 – Farmer typology ownership of olive plantations of Gera under constructed cadastral map, following a 25 year simulation under two contrasting Doom and Bright scenarios, with and without the implementation of ILIs

3.3 Results of sensitivity analysis

Results of the sensitivity analysis, like those of section 3.2, are based on averages of 20 iterations for every changing parameter under each of the four scenario storylines. This value was established after the coefficients of variation for the model outputs were calculated from an increasing number of runs. Coefficients of variation for total decline in farming population and increased abandonment extent were lowest in Doom scenarios (approximately 0.03 and 0.01 respectively) and highest for the Bright scenario with implementation of ILIs (0.16 and 0.17 respectively). While the majority of model outputs showed a stabilization of coefficient of variation values from 20 iterations, outputs related to changing average farm size and number of transitions between farmer types showed higher variation, with coefficient of variation values > 0.5.

The sensitivity analysis revealed the model particularly sensitive to the annual percentage of newcomers. Running the model with the maximum value of annual newcomers tested in the sensitivity analysis (5%) resulted in more pronounced changes in Bright than in Doom scenarios, showing an average decline in abandoned plots (from baseline value outcomes) of 39% and 18% respectively. In a "Bright + ILIs" scenario, this brings the abandonment extent on average as low as 5% by the end of a 25 year simulation. In all scenarios, increasing the amount of annual newcomers to this maximum value leads to an increase in detached farmers at the expense of the remainder two farmer types.

Of the variables influenced by ILI implementation, their ability to increase probability of having willing successors was shown as the most influential under Bright conditions. Running the model without changes to this parameter resulted in a further 20% decline in the number of farmers and an 18% increase in the extent of abandonment. Under Doom conditions, model sensitivity was dependent on more parameters; results in this scenario show a further decline in 9% of the farming population when excluding ILI influence on probability of successors, and an increase in 11% when excluding ILI influence on cultural drive or when excluding gradual declines to subsidies, compared to baseline conditions. Of the macro drivers, changes to olive oil prices most greatly affected extent of abandonment, plot intensification and amount of new generation farmers. Subsidies were on the other hand more influential to changes in farming typology composition, which generally proved considerably sensitive to changes in underlying drivers (see **Figure 12** and Supplementary Materials for comprehensive results).

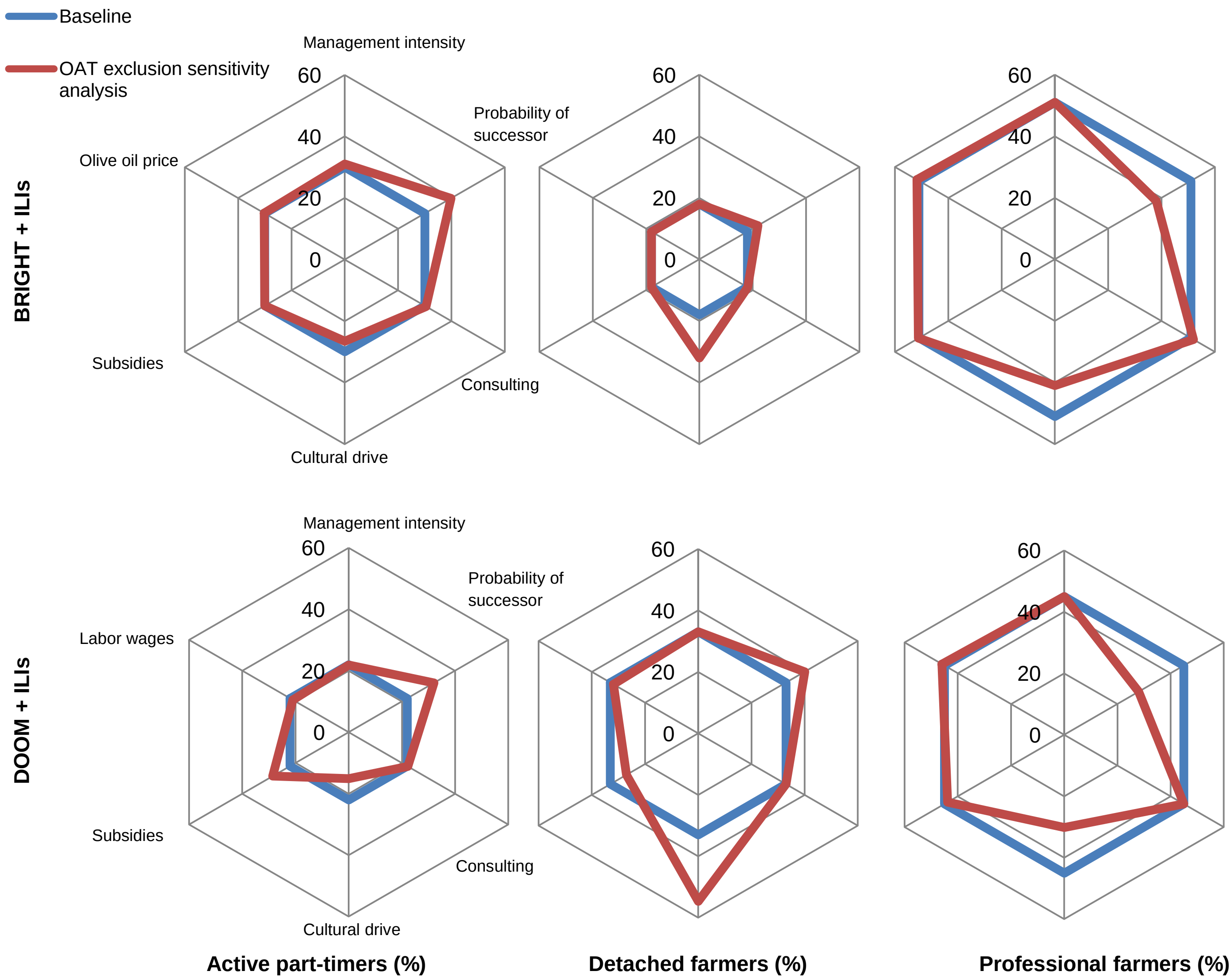


Figure 12 – Model sensitivity to parameters changed by multi-level drivers illustrated by a comparison between % farmer typology composition under baseline conditions and model runs excluding each of the affected parameters individually. Values are averages of the final yearly time-steps from 20 complete model runs.

4 Discussion

4.1 Implications of the interplay between multi-level drivers, behavioral transformations and landscape change in Gera, Lesvos

This modelling study deliberately sought to capture the divergent, alternative futures emerging from presently occurring discourses in the region of Gera. The principal findings derived from model outputs can be summarized as follows:

- Only a combination of macro-drivers supporting sectorial profitability and implementation of ILIs is able to reverse abandonment trends in an upcoming period of 25 years and sustain the local farming population, the implementation of ILIs alone is unable to prevent continuation of abandonment and collapse of farming population

- While the continuation of olive cultivation in Gera is highly dependent on the number of newcomer and successor farmers, the valorization and appreciation of the cultural landscape is dependent upon transitions away from the detached farmer type
- The hypothesized ability of ILIs to maintain and promote a cultural drive amongst adhering farmers is crucial for securing behavioral transformations towards professionalism, while subsidies play a role in the promotion of pluri-active (active part-timers) over detached farming
- Behavioral transformations are enhanced by ILIs and more frequently occur towards professionalism rather than detachment under both profitable and unprofitable macro-conditions and with or without implementation of ILIs. Sustainable intensification of the olive plantations is largely dependent upon these initiative-led transformations
- Scenario results show a polarization of the farmer typology between professionals and detached farmers, with the active-part timer type not representing the prevalent type under any simulations

The validity of these results lies primarily within its empirical derivation in an iterative, participatory approach. Comparison with similar modeling studies undertaken within and outside of the region and past trends in local landscape and population change additionally demonstrate model outputs to be within both reasonable magnitude and direction. Kaufmann et al. (2009) found economic factors to be more important than social influence in the adoption of organic farming in Latvia and revealed that it is the combination of the two factors that allows for the greatest proportion of adopters; this is comparable to our findings demanding a combination of both sectorial profitability and behavioral transformations under ILIs to reverse abandonment trends within the simulated time-frame. In modeling agricultural landscape change in Lesvos for the late 90s and early 2000s, Kizos & Spilanis (2008) found abandonment more closely related to professional farmers while hobby farmers, retired farmers and semi-professionals are forecast to maintain land in the future, similar to conditions portrayed in this study's "Doom – ILIs" simulation. While their model similarly foresees a continuation in abandonment trends, differences arise in the characterization of the farmer typology, as professional farmers were hereby characterized as largely culturally driven and equally reluctant to give up the profession, and semi-professionals found to foresee disinvestments regardless of additional sources of income. Models converge in their sensitivity to the number of newcomer farmers and succession rates. Results by de Graaff et al. (2008) similarly show extreme extent of abandonment under Doom conditions, reaching total abandonment of olive plantations for one of the target areas within their simulated period (2005-2030).

Past changes illustrate an average decline in farmer population between 1961 and 2010 of 0.89% annually (ELSTAT, 2011); suggesting a population of approximately 1166 farmers if projected to the forecast year of this study. Abandonment throughout the period of 1960 – 2012 reached a rate of 34.17 ha per year (Bürgi et al., 2015), thus resulting in an increase from the present estimated 32% abandonment extent to 51% if extrapolated to the 25th year of simulation. Both historical trends are closest to outputs forecast under Bright conditions without implementation of ILIs requiring gradual increases in subsidies and olive oil prices; a worsening of past trends would thus be forecast by the model under continuation of the status quo.

These findings bring forward propositions whose implications should be explored. A primary consideration is the perceived vulnerability of a farming community that cannot sustain itself despite widespread mobilization due to the influence of external macro-level forces, placing emphasis and responsibility for supporting the sector on governance and policy instruments. While this study did not investigate feedbacks between ILIs and macro-drivers, the financial support and policy involvement hereby conceptualized as "external" can be endogenized if structurally inherent to the organizational properties of ILIs. In a study reviewing examples of ILIs across Europe, García-Martín et al. (2016) found a lack of funding, social capital, community cohesion and institutional support to be key barriers to the success of ILIs, identifying significantly fewer exogenous ILIs (established through external forces including law, regulation or subsidy) reporting challenges than endogenous ILIs (stemming from local community initiative alone). They additionally found hybrid organizations to frequently represent initiatives, made of partnerships between local authorities and civic organizations as well as public and private actors. Opportunity for successfully preserving the local olive farming sector and associated heritage thus partially depends on the very structure and emergence of ILIs, their exogenous nature and the involvement, both financial and participatory, of multiple and diverse stakeholders. Such findings are relevant to rural development across Europe, where novel community-based governance mechanisms are "urgently" needed (Pedroli et al., 2016).

The farmer typology illustrated in this study, and the potential transitions identified, furthermore shed implications for the policy domain. Despite ILIs considerably favoring transitions towards professionalism under both Bright and Doom conditions, subsidies retain considerable influence on the farmer typology composition. Their potential to incentivize transitioning from detached to active part-timer farming in particular should be considered as the present model assumed uniform adoption of subsidies, whereas presently, some part-timer farmers may not be eligible for subsidies depending on their share of agricultural vs. household incomes, and age. Subsidies equally influenced typology composition in a Mediterranean landscape in the ABM by Acosta et al. (2014). Professionalism, hereby illustrated as inextricably linked with cultural motives and sustainably intensive management practices, is crucial to the preservation of the agricultural landscape, yet macro-drivers are unable to substantially drive transitions towards this type without operating ILIs. Of additional significance is the model outcome's dependency on the number of annual newcomer farmers arriving to Gera as well as the number of willing successors; as the number of new arrivals to the regional sector is unknown, this study provides scope for further investigation of labor migration in relation to the local olive farming sector.

4.2 Strengths and limitations of approach

Our study contributes to the growing body of literature on ABM and landscape change investigating heterogeneous decision-making behavior of land managers by making use of an agent typology approach. Its novelty partly stems from a willingness to integrate a variety of recommendations advocated for in recent ABM literature related to their development, implementation and presentation. The model sought to identify and provide spatially explicit dynamics without representing spatial outputs too sensitive or realistic (Barnaud et al., 2013). It utilized collected and targeted empirical data for the delineation of decision-making pathways and behavioral attributes of agents (Filatova et al., 2013). It incorporated a scenario approach, investigating futures by changes occurring in multi-level drivers (Caillault et al., 2013). It furthermore aimed to provide specific conceptual grounding representing human decision-making (Schlüter et al., 2017) simulating transformations beyond the starting generation, an outlook often dismissed within ABM literature because of the relatively short time-scales typically addressed. Particular emphasis was placed on developing the model in collaboration with the local community in an incremental/iterative process in an effort to ensure legitimacy and saliency of the model (Brown et al., 2016). The stakeholder workshop proved crucial as it allowed for a closer discussion of model processes and resulted in the derivation of many novel or improved representations, while witnessing enthusiastic participation by the local stakeholder community and confirming the case for utilizing ABMs as explorative discussion tools in a set-up that favors their opening to critique (Johnson, 2015).

Contributions from both cultural landscape experts and the local farming community within the workshop conversely also brought to light limitations of the model, often inherent to ABM research in general. Not all insights from the workshop were integrated in a refined model (**Table 4**), several in an attempt to avoid over-complexity, yet risking oversimplification (Polhill et al., 2010). An important limitation is the partial consideration of system ruptures and incorporation of "secondary feedback loops" as advocated by Le et al. (2012). Agents in the present model have internal memory and behave according to annual, in relation to past, events. Progressive increase or decrease in scale of the farming system may breach an area threshold and result in a type-switch, altering behavioral attributes by which the farmer undertakes decisions. Such instances of *cumulative* change are however limited to scale-based decision-making behavior of individual farmers, and are absent in the consideration of, for example, cumulative responses by individual or collective agents to increasing ILI membership, advancing abandonment, oil price decline, etc. which may not progress linearly through time or may trigger (or be triggered by) novel responses. While these additional feedback mechanisms were not explored in the model, the present set-up allows for an initial exploration of some of these dynamics, as switches and underlying drivers can be triggered at any time-step simulating abrupt changes to the system.

The heavy reliance on probabilistic processes revealed itself a considerable source of uncertainty in certain outcomes as illustrated via the sensitivity analysis, investigation of locational variability and coefficients of variation. While empirical datasets informed agent behavior and provided a basis for weighing the influence underlying drivers hold within decision-making, it is important to note the present model set up does not represent a universal or absolute configuration; rather, it sheds light on conceivable alternative futures while encouraging the future alteration of parameters and processes in efforts to bring the model closer to novel insights or for the further utilization of the model as an explorative tool for discussion.

Questions and actions remain in fulfilling aims of "investigating the role of ABMs in stimulating societal discussions about management options". Model presentation and discussion has thus far included a relatively homogeneous audience; particularly within the local community, largely limited to farmers. In light of results demonstrating the necessity of "exogenous" involvement, discussion of the implications of the envisaged alternative landscape futures should aim to incorporate a more diverse range of decision-makers and landscape users. While the ABM did succeed in stimulating relevant discussion amongst all the present participants, the workshop turnout remained low. Questions posed throughout the workshop to the local community investigating the expected number of ILI-adherent farmers in a "best-case" scenario revealed participants were largely divided in their predictions, mirroring findings of the primary interviews portraying a society split in pessimistic vs. optimistic forecasts on the future of the sector (see Zagaria et al., 2018). Despite the questionable validity of such statements due to the low representativeness of the sample, these findings all cast extensive emphasis on the seemingly pivotal role of community engagement.

5 Conclusions

This study provides a mixed-method exploration of alternative futures of a Mediterranean cultural landscape prone to abandonment via a novel conceptualization of behavioral transformations while placing emphasis on generational succession. It exemplifies an approach to study complex human-environment system interactions by means of combining an ABM in a stakeholder interaction context for consideration to the future management of cultural landscapes. The constructed model is able to capture and illustrate the cumulative effect of the identified dynamics in terms of demographic and landscape transitions, and, in doing so, draws attention to the critical hindrance structurally deficient policies and initiatives can inflict on the resilience of rural communities and agricultural heritage. While the model deliberately presents scenarios whose names are connotative of extreme or even unrealistic conditions, these scenarios emerged from the voices of a farming community that rejects a continuation of the status quo. The findings pave the way for improving rural development in the region and additional research across the valuable cultural landscapes of the world to further address future management of cultural landscapes; further insight is needed in narrowing focus on new generation farmers and labor migration.

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8 Supplementary Material

8.1 ABM Description following Overview, Design Concepts and Details (ODD + D) template

Table S1 - Model description follows the template set out by the ODD + D protocol presented by Müller et al. (2013), expanding and modifying the original ODD protocol (Grimm et al., 2006, 2010) to more closely elaborate on the human decision-making components in ABMs

Outline (→template)		**ODD + D Model description**
Overview	Purpose	The purpose of this study is to explore how Integrated Landscape Initiatives (ILIs) and macro-level drivers alter agent behavior and consequentially affect landscape change, unravelling complex human-environment dynamics at play within cultural landscapes prone to agricultural abandonment. By informing the model empirically and utilizing an iterative model development approach in collaboration with experts in cultural landscape change and local farming community members, the study aims to promote societal discussions for the reversal of abandonment trends within the case study area and beyond. As such, the model is designed primarily for the scientific, policy and farming communities interested in similar dynamics. The ABM specifically aims to: (1) Model and evaluate the extent to which underlying drivers affect landscape changes in the region of Gera under a "Bright" and "Doom" scenario set to respectively disfavor and favor the continuation of abandonment processes by affecting the profitability of the agricultural sector (2) Model and evaluate the extent to which the implementation of ILIs mitigates or enhances changes under each scenario influencing behavioral attributes of agents alone (3) Enhance representations of behavioral transformations, specifically towards new generation farmers
	Entities, state variables and scales	The model is based on attributes belonging to one of five separate entities: individual farmers, patches (pixel-level units comprising fields), fields, farms (collection of fields belonging to the same farmer) and a global environment determining external influential processes, i.e. the state of the macro drivers. Both fields and farmers are coded as "agents". **Table S3** presents the comprehensive list of all attributes belonging to each of the five entities, illustrating the attribute name as referred to in the model code alongside a description of the attribute, units of measurement and value ranges. Exogenous factors acting as drivers of change in the model explicitly relate to the macro-level drivers of olive oil prices, labor wages and agricultural subsidies. ILIs were not modelled as separate collective entities but operated if "activated" in a model run by altering behavioral attributes of adherent farmers. The model is spatially explicit and geo-referenced to cover the former municipality of Gera, Lesvos (87km^2). It makes use of spatial datasets related to land-cover, slope, cadastral boundaries, accessibility to road network, road network, land suitability and location of towns. All landscape changes occur within the olive grove land-cover class only as delineated within the 2012 land cover dataset. The baseline year was set to 2012 according to the most recent land cover dataset available. The model runs at annual intervals for a total of 25 years (time-steps).
	Process overview and scheduling	The model begins with a computation of the total farmer population. Every year 1% of the total farmer population is added as new arrivals, their farmer type being set to match the predominant type in the municipality that given year. All farmers age one year and some leave the system as they reach their individual life expectancy, set according to country statistics. If a successor is present it will inherit land and the majority of parent characteristics, if no successor is present all land is abandoned. A successor's cultural drive is not directly inherited but re-established under probabilities for their inherited farmer type, allowing for the possibility that the parent farmer had switched farmer-type and may therefore pass on different motivational values to the successor. Similarly, in the case of ILIs being considered in the model run, a successor farmer will re-consider joining ILIs and will not necessarily join despite the parent farmer's membership. Both new arriving farmers and successors are considered "new generation" farmers. Every year all farmers calculate their farm yield (based on slope and management intensity), profits and costs to determine their annual wealth and assess how this compares to the previous years'. Accessibility of a farmer's fields influences the farmer's transport costs. Macro drivers of olive oil prices, subsidies and labor wages are updated based on annual rates of change and hereby affect a farmer's annual wealth computation. Following an assessment of new total land area and wealth, farmers decide whether they have the possibility to expand their system or whether they are better off scaling-down or continuing under present conditions. The probability of an action taking place is set according to a farmer's goals (cultural or non-cultural), their level of schooling, past actions, whether their profits have been increasing or declining, their age and imitation strategy. While cultural farmers choosing to shrink their system will consider abandoning rather than selling, the opposite is true for

		non-cultural farmers seeking profit maximization. A single plot is assigned to a decision regarding the purchase or selling/abandonment of land; the plot is selected according to whether it has the highest or lowest land suitability value respectively. Following a period of abandonment of 5 years, fields witness a land-cover transition to wooded grassland and shrub, after an additional period of abandonment of 15 years the fields are considered forested. As land undergoes land-cover changes (to shrub or forest) the land suitability value of land decreases, in turn decreasing the likelihood of abandoned fields being purchased if more suitable plots are available for sale within the market. If a farmer buys a plot that was previously abandoned, the farmer undergoes a one-off land conversion cost and the plot undergoes an increase in land suitability value. Type-switches may occur in two instances. Following actions undertaken in the given year and depending on a farmer's cultural drive, age, declining or increasing profits and farm area size, a farmer may undergo a type-switch. These may result in changes to a farmer's management intensity and hired labor units, leading to de-intensification or intensification of a farmer's land. Direct type-switches between disengaged farmers and professional farmers are not considered. In a second instance, if a farmer reaches retirement age of 65 and does not have a willing successor, they will continue farming under the present type unless they are of the professional type, in which case they will switch to the active part-timer type and extensify their system. If ILIs are activated in the model run, each farmer that is not already a member will consider joining. Their diffusion is enhanced by imitating farmers responding to an increasing portion of farmers in the region having already adhered to the initiatives, the inquiring farmer's cultural drive, their education level and use of external consultations. Joining an ILI in turn increases a farmer's management intensity to the highest level (assuming sustainable intensification), potentially changes a farmer's motivational values from non-cultural to cultural, introduces the farmer to external consultancies and increases the probability that the farmer will have a willing successor.
Design concepts	Theoretical and empirical background	General concepts underlying model design reside within behavioral theories as well as broad agronomic and economic processes. Influential macro drivers relevant for sectorial profitability and farmer's annual wealth computation were derived from de Graaff et al. (2009). Limited availability of spatial datasets related to biophysical conditions of relevance to agronomic yields resulted in the more ad-hoc approach adopted for yield computation, reliant solely upon slope of fields, frequency and intensity of the farmer's management practices and inputs and hired labor units. Returns to labor are assumed as management intensity and hired labor are weighted differently within revenue and cost computations. Lack of spatial information regarding land ownership furthermore resulted in the constructed hypothetical cadastral dataset, informed by land-use GIS data from 2012, local census data from 2011 (ELSTAT, 2011) and spatial trends identified in in-depth interviews with 100 farmers of the municipality. Assumptions behind farmer decision-making are based on a combination of established theory, ad-hoc rules and empirical observations. Farmers are boundedly rational and influenced by cultural and economic goals as revealed via farmer interviews and confirmed in a local stakeholder workshop. Empirical evidence from the interviews and workshop furthermore revealed age to be an influential factor in land-based decision-making. Farmers are assumed to favor the repetition of past actions in their farm management decision-making and to favor transition to alternative non-agricultural employment if they have attained a higher level of schooling, processes elaborated or similarly adopted in Valbuena et al. (2010) and Acosta et al. (2014) respectively. All farmers are assumed to receive agricultural subsidies in equal amounts, thus perceiving changes equally. Spread of ILI membership takes place according to the Theory of Planned Behavior, utilizing a similar approach to that modelled by Kaufmann et al. (2009); relative contribution (weights) of the different components were assumed to be equal. The assumed ability of ILIs to alter agent behavior and promote passing of land to successors draws on respective findings of García-Martín et al. (2016) and Sottomayor et al. (2011). Input data related to farmer and field attributes was largely aggregated at the farmer-type level. The application of these design concepts within the model is elaborated within the manuscript in Section 2.4.
	Individual decision-making	Decision-making takes places at the individual (farmer) level and specifically relates to farm expansion or shrinking (affecting one plot per annual time-step), farm intensification or de-intensification (affecting the farm system as a whole), decisions to join ILIs and decisions to undertake a type-switch. These decisions are not independent of each-other, as altered farmer behavior from ILI membership or farmer type transitions influence the way farmers choose the management and scale of their farm, and vice versa. No optimization or utility maximization approaches are adopted within decision-making. Rationality lies within all farmers wishing to make a profit from farming by purchasing the most productive plots and selling or abandoning the least. While non-cultural farmers sell their plots as part of their profit-making goals, cultural farmers are more reluctant to scale down and only do so by abandoning their plots, thus not pursuing profit-making in this decision-making aspect. Cultural farmers furthermore wish to see a revitalization of their sector and agricultural heritage, and in consequence are more likely to adhere to ILIs and intensify their systems by increasing their knowledge base. Decision-making is ultimately dependent on a farmer's

		agricultural knowledge assumed within a farmer's past experiences and interactions, and thus on a farmer's willingness to assimilate knowledge from external sources. Decisions to expand or shrink the farming system and adhere to ILIs are dependent on the occurrence of a series of farmer agent attributes, alongside the farmer's accrued wealth and total farmland area. The more relevant attributes are "present" for farmers, the more likely they are to undertake the action. The decision maintains a probabilistic element as randomly generated numbers are evaluated against the farmer's likelihood of action probabilities. Agents adapt their decision-making behavior as a result of changing exogenous and endogenous drivers. Macro drivers directly affect a farmer's annual wealth computation by increasing or decreasing agricultural subsidies, labor wages and olive oil prices. These changes influence a farmer's ability to purchase new land and affect likelihood of scaling down system. Consequentially, exogenous factors may affect type-switches indirectly by altering a farmer's total farmland area and from the assessment of present profits in respect to the profits made in the previous year. ILI membership furthermore alters agent behavior, directly for member farmers by promoting higher intensity farm management, cultural goals and interactions for knowledge transfer. Indirectly, growing ILI membership promotes transitions towards professionalism and positively feedbacks to more farmers adhering, primarily through imitating and consulting farmers. Spatial aspects play a role in decision-making in the computation of annual yields (based on slope), in the selection of plots for buying or selling transactions (dependent on the land suitability layer) and in the distribution of plot ownership (cadastral layer) dependent on survey-derived probabilities of occurrence of farmer type plot ownership across the land suitability layer. Temporal aspects play a role in decision-making by accrued wealth and farmland area; thresholds related to each of these attributes affect decision-making regarding purchase of plots and type-switches. Farmer agents do not explicitly consider uncertainty or risk in their decision-making.
	Learning	Learning is dependent on interactions of farmers (via imitation and external consultations) and past experiences. Farmers are more likely to pursue a certain action if they have already undertaken it in the past, modeling internal memory. It is also implied as part of the behavioral changes that occur from adhesion to ILIs manifested in changes to management intensity and behavioral attributes, potentially driving a farmer towards cultural goals. Collective learning is not considered.
	Individual sensing	Farmers sense changes to olive oil prices, subsidies and labor wages. They are aware of land suitability values of plots on sale (which represent their financial value) and of the predominant farmer-type in the region. As farmers join ILIs they start making use of external consultancies. A farmer is not aware of the state variables of any other farmer in the municipality. Costs of joining ILIs or of gathering information by means of consultancies are not directly considered in the model. However, by increasing management intensity as a result of membership and consultations, farmers will witness a change in their yearly revenue as higher costs are assumed from new inputs as well as improved yields. The sensing process is not considered to be potentially erroneous.
	Individual prediction	Farmers do not aim to predict future conditions; they base their yearly decision-making on their current situation, past actions and comparison of present and past profits.
	Interaction	Farmers directly interact between themselves via imitating and consulting farmers, responding to the predominant farmer type within the region and the number of farmers joining ILIs. If the majority of farmers in the region are of the professional type, imitating farmers are more likely to expand their farming systems. If either of the remaining two farmer types presents the predominant type in the area, imitating farmers are more likely to disfavor system expansion. Imitation is set to the predominant farmer type as opposed to proximity-based neighbor imitation as farmers in the region largely own several plots scattered across the case study area. ILIs, if activated, are by definition seen as imposed and not emergent. They change behavioral properties of adherent farmers, maximizing their management intensity, instating a cultural drive, increasing likelihood of having a willing successor and introducing the farmer to external consultancies. Imitating and consulting farmers are more likely to adhere to ILIs. Indirect interactions occur as a result of buying and selling or abandonment of land; as these decisions occur within a finite space they reduce the possibilities of other farmers undertaking similar decisions. Furthermore, values related to land suitability are normalized, thus plot selection is dependent on the plots placed on sale by all farmers.
	Collectives	Collectives represent the social networks present within the model. While ILIs are not represented as separate agents, their effect as a collective is modelled by altered farmer behavior of adherent farmers. Their diffusion is determined by a non-member farmer's attitude, subjective norms and perceived behavioral control, as modelled by Kaufmann et al. (2009), utilizing Theory of Planned Behavior to explore diffusion of organic

		farming practices by means of an ABM. A farmer's attitude was equated to the farmer being culturally vs. non culturally driven, subjective norms are set according to a farmer being an imitator and the share of the farming population which has adhered to ILIs while perceived behavioral control is a function of a farmer's education level and use of external consultations.
	Heterogeneity	The farming community is considered heterogeneous as farmers have differing values for their attributes. While farmers belonging to the same type are more likely to share similarities in attributes, these remain set according to type-specific probabilities of occurrence, thus maintaining some within type heterogeneity also. Maximum manageable farm size is the same for all farmers, representing the value past which farmers will no longer choose to expand their system despite sufficient wealth. Once retired, this value declines yearly and equally for all farmers. The model includes type-specific area constraints, notably the maximum manageable farm size for active part-timers and the minimum manageable farm size for professional farmers, both of which implement equal values for all type members. The third sub-module (decide and implement actions) runs the same functions for all farmers in the calculation of their yearly revenue and subsequent decision-making. While cultural farmers that opt for scaling-down of system will choose to abandon, non-cultural farmers will opt to sell. Because model functions are run individually for all farmers and are based on the occurrence of a set of field or farmer attributes, they result in heterogeneous values across the farming community.
	Stochasticity	Several processes within the model contain stochastic elements. Agent attributes which are randomly set are the past profits of starting farmers (stable increasing or decreasing), the number of labor units (between 1 and 6) set if the farmer is hiring labor and the age of newcomer or successor farmers, set randomly between a minimum of 18 and maximum of 38 years of age. The initial abandonment extent is set to 32% of fields (based on historical decline in yield productivity in maximum years) selected randomly from the cadastral layer, while plots purchased by newcomer farmers at every time-step are also selected randomly. The model's probabilities were informed empirically or following model calibration and sensitivity analysis, the latter referring to probability values for undertaking a land-based action, undergoing a type-switch, joining ILIs or having a willing successor following ILI membership. These values maintain a partially stochastic element. As the interview data determines the probability of an agent of a certain farmer type having certain attributes or attribute values, the model runs random draws based on these probabilities.
	Observation	Key outputs considered are related to the magnitude and spatial extent of agricultural abandonment and re-wilding taking place under the different scenario storylines, as well as changes to total farming population and typology composition, assessed with and without the implementation of ILIs. Additionally, landscape changes related to intensification and de-intensification of cultivated systems are assessed under the different scenario conditions, and an understanding of generational changes in farmer behavior quantified. These emerging outputs are recorded in the ABM interface at every time-step
Details	Implementation details	The model was built in NetLogo version 5.3.1 making use of the GIS extension. Output spatial datasets and the ABM will be made publicly available upon acceptance of the paper (see corresponding author's departmental and/or funding project webpages)
	Initialization	At the time of initialization, 32% of fields are considered abandoned for more than 5 years and are thus displayed in the interface as wooded grassland and shrub areas within the olive plantations. This is the same in every model run, however the field selection process is stochastic and thus the abandoned landscape pattern differs in each model run. As farmers are stripped of ownership of their field once it becomes abandoned, the number of farmers at initiation also varies depending on the 32% abandoned field selection, as farmers who lose all their fields will quit the system altogether. In the start year, the predominant farmer type is always the detached farmer according to the farmer typology distribution identified within the interviewed sample. Each group of fields with the same Farmer ID generates its managerial farmer based on the imported cadastral map via the GIS extension; farmers are then parameterized and their attribute values set: past profits are randomly allocated as declining, stable or increasing, life expectancy is set and the GIS imported farmer type informs the probability of the remainder attributes occurring. All runs, irrespective of scenario and ILI activation, begin with 11% of the farmer population as ILI members (a value not influential in a model run whereby ILIs are not activated); the value was obtained by the portion of farmers identified as social cooperative members also within the interviewed sample. The underlying drivers begin at equal values within both scenario storylines.
	Input data	With the exception of imported GIS layers, the model does not use input data from external sources.
	Sub-models	See Supplementary Materials 8.2

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8.2 Sub-models

Table S2 – Descriptive outline of model commands following initialization (i.e. run at every time-step) listed in chronological order; illustrating the "sub-models - details" component of the ODD + D protocol presented by Müller et al. (2013), expanding and modifying the original ODD protocol (Grimm et al., 2006, 2010) to more closely elaborate on the human decision-making components in ABMs

Sub-model cluster	Command	Task description
Update	Rest timer	*Reset timer*
Demographics	Compute predominant farmer type	*Computes the predominant farmer type across the region and displays type on interface*
	Update farmers	*Increase age of all farmers by one year, re-set their age class and maximum manageable area size if retired*
	Death	*Farmers that reach their individual life expectancy pass land on to successor if present (who inherits or re-sets attributes), if no successor is present fields are abandoned*
	Retirement	*Farmers that reach 65 years of age pass land on to successor if present (who inherits or resets attributes), if no successor is present professional farmers will switch to the active part-timer type and extensify their farm system, while the remainder farmer types continue farming under increasing area constraints*
	Newcomers	*The number of newcomers is set to 1% of the annual farmer population. Newcomer farmers are assigned the predominant farmer type and begin farming by acquiring one vacant field in the region. If the field had been placed on sale, the selling farmer gains profit from sale of field. If the field was previously abandoned, the value of the field will increase due to its conversion from wild to cultivated state*
Scenario-setting	Scenario settings	*The starting values to the macro drivers altered by scenarios are set (these are equal under both Bright and Doom conditions). Annual rates of change for macro drivers under Bright and Doom conditions are also set, depending on which scenario is chosen in the interface*
	ILI implementation	*Only runs if ILIs are activated in the interface for the simulation. If so, farmers which have decided to adhere to ILIs will undergo annual increase/maintenance of high management intensity, will adopt/maintain a cultural drive, will make use of external consultations and calculate a new (higher) probability of having a willing successor*
Deciding and implementing actions	Computation of drivers	*The values of macro-drivers are adapted according to the annual rates of change*
	Computation of yield	*Computed at the patch level based on the patch slope value. Yield is then summed across all fields belonging to a farmer; farm yield is then calculated in consideration of the farmer's management intensity and hired labor units*
	Computation of production costs	*Calculated based on a farmer's management intensity and farm size*
	Computation of transport costs	*Calculated based on the average accessibility of a farmer's fields; field values are then summed to provide a total cost value per farmer*
	Computation of wealth	*Farmers calculate total costs, summing transport and production and conversion costs if plot was purchased in an abandoned state. Annual profits are calculated from the annual costs and yields and accounting for yearly oil prices, subsidies and labor wages. The annual profit is added to a farmer's accrued wealth.*
	Normalize land value	*The land value of fields is normalized between 0 – 1*
	Decide probability of action	*Farmers calculate the annual minimum value of wealth required for purchases based on the most expensive plot on sale that given year. If farmers have enough wealth but have reached the maximum manageable land area they will decide to continue without shrinking or expanding their farm. If they have enough wealth for buying and have not reached the maximum manageable farm area, they will proceed to determining action by calculating their probability to buy or continue with no change [determine action function 1]. If farmers do not have the required minimum wealth for land purchase, they will proceed to calculating their probability to shrink farm or continue with no changes [determine action function 2].*
	Determine action	*Determine action function 1: these farmers calculate their probability to buy based on the occurrence of a set of attributes, notably: past expansion, imitation*

		in a prevailing professional context, and not belonging to the retired age class. The probability is run against a random draw to determine whether the farmer buys or continues. *Determine action function 2: these farmers calculate the probability to shrink their system; probability increases based on past profits not showing an increase, belonging to the young age class, having shrunk in the past, having attained a higher level of schooling and belonging to the younger age group. If farmers are culturally driven they opt for abandonment, if they are not culturally driven they opt for selling. The probability to shrink is run against a random draw to determine whether the farmer shrinks or continues.*
	Assign plot to action	*A buying farmer will be assigned the plot with the highest land (suitability) value that is currently either placed on sale or abandoned. If the field had been placed on sale, the selling farmer gains profit from sale of the field. If the field was previously abandoned, the value of the field may increase due to its conversion from wild to cultivated state and the buying farmer will incur a cost. Shrinking farmers will sell or abandon the plot with the lowest land (suitability) value. While farmers who place their plots on sale will continue management until they are sold, farmers who abandon "loose" ownership and may thus no longer perform any commands over their former plot. Farmers past buying or shrinking status is updated accordingly.*
	Update sub-process	*A farmer recalculates his total farm area following transactions. A farmer calculates whether new profits have been stable, increasing or decreasing compared to the previous years and updates attributes accordingly.*
Establishing individual typologies	Type-switch	*Farmers below retirement age hereby may undergo type-switches. Active part-timers having previously opted to continue without expansion or shrinking of system, if above 50 years of age, not culturally driven and having witnessed stable or declining profits will run a probability to switch to the detached farmer type. Alternatively, if their farm size is above the maximum manageable farm size for their category they will run a probability to switch to the professional type. Detached farmers who are culturally driven and have a farm size at least half of the maximum requirement for active part-timers will transition to the active part-timer type. Professional farmers whose farm size is below the minimum area threshold required for their farm type will transition to the active part-timer type. All type-switch changes are accompanied by farm intensification or de-intensification accordingly. Fields are updated to their new and respective owner farmer types.*
Consider ILI membership	Consider ILI membership	*Farmers that have not yet adhered to ILIs consider joining based on their level of schooling, use of external consultations, imitation strategy, proportion of farming population that has already adhered to initiatives, cultural drive. The probability is run against a random draw to determine whether the farmer joins or not.*
Implement land-cover changes	Implement land-cover changes	*Keeps track of length of abandonment period of fields. Implements land-cover changes resulting from intensification of fields, de-intensification of fields, short and long term abandonment, on both field and patch attributes. Land (suitability) values are updated following long or short term abandonment.*
Update	Tick	*Time advances by one year*
	Show timer	*Time is shown*
	Update view	*Imports, establishes and updates settings for how spatial layers are viewed in the interface – keeps track of visualizing changing land-cover and land ownership*

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8.3 Attributes of model entities

Table S3 – List of attributes according to model entities; attribute names as referred to in the model code are specified and described. Attributes related to imported GIS data layers or attributes that are "duplicated" via normalization are only listed once to avoid redundancy. Attributes that are specified as "empirically derived" relate to the empirical derivation of distribution or frequency across the farmer population

Entity	Attribute name	Description	Value(s)	Notes
Farmers (agents)	farmer-id	*Individual farmer ID*	1 – 1566	Discrete
	farmer-type	*Farmer type based on constructed typology*	1 = Active part-timer 2 = Detached farmer 3 = Professional farmer	Categorical Empirically derived
	farmer-age	*Age of farmer (years)*	18 - ~80	Discrete Farmers age one year with every time-step, maximum age is probabilistic, based on 4 standard deviations of the life expectancy of the country Empirically derived
	farmer-young	*Farmer belongs to the young age class (18 – 34 years)*	0 ; 1	Binary, yes/no Empirically derived
	farmer-ma1	*Farmer belongs to the younger middle-aged class (35 – 49 years)*	0 ; 1	Binary, yes/no Empirically derived
	farmer-ma2	*Farmer belongs to the older middle-aged class (50 – 64 years)*	0 ; 1	Binary, yes/no Empirically derived
	farmer-retired	*Farmer belongs to the retired age class (above 65 years)*	0 ; 1	Binary, yes/no Empirically derived
	max-age	*Maximum age a farmer will live (years)*	~80	Probabilistic based on 4 standard deviation of the life expectancy of the country
	farmer-intensity	*Farm management intensity, assuming sustainable intensification, inclusive of family labor but excluding additional hired labor*	1 = low-intensity 2 = medium-intensity 3 = high-intensity	Categorical Empirically derived
	my-field-list	*Number of fields belonging to a farmer*	1 - 11	Discrete
	farmer-wealth	*Accrued wealth of farmer (unit-less)*	~ -90 - ~ 50	Continuous
	farmer-new-profit	*Annual farmer profit (unit-less)*	~ -5 - ~ 2	Continuous
	farmer-past-profit	*Profit from previous year (unit-less)*	~ -5 - ~ 2	Continuous
	farmer-past-profit?	*Whether profits have stabilized, increased or decreased in this year when compared to the previous year*	1 = declining 2 = stable 3 = rising	Categorical
	farmer-desired-action	*Whether farmers wish to buy more land, scale down or continue without expansion or shrinking of system*	0 = undecided 1 = run probability equation 1 (choice to buy or continue) 2 = run probability	Categorical

			equation 2 (choice to continue or abandon/sell)	
	p-buy	*Probability of buying a plot*	0; 0.03; 0.09; 0.15; 0.21; 0.27	Discrete Set following model calibration
	p-sellp	*Probability of selling a plot*	0; 0.03; 0.09; 0.15; 0.21; 0.27	Discrete Set following model calibration
	p-abandonp	*Probability of abandoning a plot*	0; 0.03; 0.09; 0.15; 0.21	Discrete Set following model calibration
	p-social	*Probability of joining (or having joined) an ILI*	0 - 0.24	Continuous Set following model calibration
	p-switch1	*Probability to undergo type switch: detached farmer to active part-timer*	0.21	Set following model calibration
	p-switch2	*Probability to undergo type switch: active part-timer to professional farmer*	0.21	Set following model calibration
	p-switch3	*Probability to undergo type switch: active part-timer to detached farmer*	0.21	Set following model calibration
	p-switch4	*Probability to undergo type switch: professional farmer to detached farmer*	0.21	Set following model calibration
	p-successor	*New probability of having a successor following ILI membership*	0.3	Set following model calibration
	w-pbc	*Farmer's perceived behavioral control*	0; 0.5; 0.7	Discrete Set following model calibration
	w-sn	*Farmer's subjective norms*	0 - 1	Continuous Set following model calibration
	w-attitude	*Farmer's attitude*	0; 0.7	Discrete Set following model calibration
	continue	*The famer has decided not to buy, sell or abandon fields in this time-step*	0 ; 1	Binary, yes/no
	buyer	*The farmer has decided to buy a field*	0 ; 1	Binary, yes/no
	sellp	*The farmer has decided to sell a field*	0 ; 1	Binary, yes/no
	abandonp	*The farmer has decided to abandon a field*	0 ; 1	Binary, yes/no
	is-imitator	*The farmer is an imitator*	0 ; 1	Binary, yes/no Empirically derived
	is-consulting	*The farmer is making use of external consultations*	0 ; 1	Binary, yes/no Empirically derived (at initiation)
	is-cultural	*The farmer is culturally driven*	0 ; 1	Binary, yes/no Empirically derived (at initiation)
	is-social	*The farmer is a member of an ILI*	0 ; 1	Binary, yes/no Empirically derived (at

				initiation)
	is-educated	*The farmer has a higher level of schooling*	0 ; 1	Binary, yes/no Empirically derived (at initiation)
	new-generation	*The farmer is a new generation farmer, i.e. either a successor or a new arrival*	0 ; 1	Binary, yes/no
	has-successor	*The farmer has a willing successor*	0 ; 1	Binary, yes/no Empirically derived
	hired-labor	*The farmer hires labor*	0 ; 1	Binary, yes/no Empirically derived
	hired-unit	*Hired labor units, if the farmer hires labor*	1 - 6	Discrete
	farm-size	*Size of farm (m^2)*	1 000 – 200 000	Continuous
	farm-yield-norm	*Farm yield (biophysical productivity of land only)*	0 - 1	Continuous (normalized)
	final-yield-norm	*Farm yield (biophysical productivity of the land, management intensity and hired labor units)*	0 - 1	Continuous (normalized)
	farm-prod-cost	*Production costs from intensity of inputs and hired labor units*	0 - 3	Continuous
	trans-cost-norm	*Transport costs related to average accessibility of fields*	0 - 1	Continuous (normalized)
	costs-norm	*Production costs (considering labor wages) and transport costs*	0 - 1	Continuous (normalized)
	conversion-cost	*One-off cost of bringing abandoned field back into production*	0.5	Set following calibration
	farmer-past-buyer	*The farmer has bought land in the past*	0 ; 1	Binary, yes/no
	farmer-past-shrunk	*The farmer has sold or abandoned land in the past*	0 ; 1	Binary, yes/no
	max-f-size	*Maximum manageable farmland a farmer can own, once attained a farmer will no longer buy even though he has enough wealth. This area is smaller for retired farmers (m^2)*	200 000	Empirically derived, assessed in model calibration
	max-f-size-type1	*Maximum farm size an active part-timer can farm before switching to professional type (m^2)*	150 000	Empirically derived, assessed in model calibration
	min-f-size-type3	*Minimum farm size a professional farmer can farm before switching to active part-timer type (m^2)*	10 000	Empirically derived, assessed in model calibration
	min-wealth	*Minimum wealth required by farmers to buy additional land (unit-less)*	50 * (highest value plot on sale)	Set following model calibration
	switch-1	*Type switch: detached farmer to active part-timer*	0 ; 1	Binary, yes/no

	switch-2	*Type switch: active part-timer to professional farmer*	0 ; 1	Binary, yes/no
	switch-3	*Type switch: active part-timer to detached farmer*	0 ; 1	Binary, yes/no
	switch-4	*Type switch: professional farmer to detached farmer*	0 ; 1	Binary, yes/no
	extensified	*The farmer has de-intensified his fields at any point in simulation (only cleared if intensified subsequently)*	0 ; 1	Binary, yes/no
	intensified	*The farmer has intensified his fields at any point in simulation (only cleared if de-intensified subsequently)*	0 ; 1	Binary, yes/no
Patches	land-cover	*Land-cover of patch*	3 = cultivated olive 10 = intensified cultivated olive 11 = de-intensified cultivated olive 12 = wooded grassland and shrub encroachment from abandonment (5 years) 13 = Forest encroachment from long-term abandonment (20 years)	Categorical
	access	*Patch accessibility value (i.e. proximity of patch to road network)*	0 - 1	Continuous (normalized)
	slope	*Patch slope value*	0 - 1	Continuous (normalized)
	value	*Patch land (suitability) value*	-0.6 - 0.8	Continuous
	p-farmer-id	*All the patches owned by the same farmer have the same patch-level Farmer ID, or Farm ID, this attribute connects patches to proprietor farmers*	1 - 1566	Discrete
	p-field-id	*Field ID, all the patches belonging to the same field have the same Field ID, this attribute connects patches to communal fields*	1 - 6247	Discrete
	p-yield	*Patch yield*	0.9 - 10	Continuous
	mytype	*Farmer type of patches' proprietor farmer*	1 = Active part-timer 2 = Detached farmer 3 = Professional farmer	Categorical
Fields (agents)	f-id	*Individual field ID*	1 - 6247	Discrete
	f-farm-id	*Farm ID, all the fields owned by the same farmer have the same Farm ID (this value is equal to the farmer ID value, thus connecting*	1 - 1566	Discrete

		farmers to their fields)		
	f-yield-norm	*Yield of field, sum of its patch yield values*	0 - 1	Continuous (normalized)
	f-access	*Accessibility value of field, i.e. proximity of field to road network, average of its patch proximity values*	0 - 1	Continuous (normalized
	farmer-type	*Farmer type of field's proprietor farmer*	1 = Active part-timer 2 = Detached farmer 3 = Professional farmer	Categorical
	f-value-norm	*(Suitability) value of field, sum of its patch suitability values*	0 - 1	Continuous (normalized)
	f-landcover	*Land-cover of field*	3 = cultivated olive 10 = intensified cultivated olive 11 = de-intensified cultivated olive 12 = wooded grassland and shrub encroachment from abandonment (5 years) 13 = Forest encroachment from long-term abandonment (20 years)	Categorical
	my-f-patches	*Attribute connecting patches to proprietor field*	1 - 6247	Discrete
	my-farmer	*Attribute connecting fields to their proprietor farmer*	1 - 1566	Discrete
	field-size	*Size of field (m^2)*	1 095 - 29 021	Continuous
	is-abandoned	*The plot has been abandoned*	0 ; 1	Binary, yes/no
	is-for-sale	*The plot has been placed on sale*	0 ; 1	Binary, yes/no
Globals	predominant-type-area	*Predominant farmer type in Gera in given time-step*	Active part-timer Detached farmer Professional farmer	Categorical
	labor-wage	*Starting value of labor-wage*	1	Altered under Bright or Doom condition by varying annual rates of change
	oil-price	*Starting value of olive oil price*	1	Altered under Bright or Doom condition by varying annual rates of change
	subsidy	*Starting value of agricultural subsidy*	1	Altered under Bright or Doom condition by varying annual rates of change

8.4 Technical information on methodology

(A) Construction of spatial datasets

Cadastral dataset:

Method - Thiessen polygons were generated from the plot point data, clipped to olive cover extent and subsequently skewed according to plot size information using the cartogram software ScapeToad Version 11 (Chôros Laboratory, 2016) with mass as the metric variable. While this constructed cadastral dataset resulted in a considerably smaller area range for plot and farm sizes then can be expected within the agricultural region (particularly through the exclusion of large scale farm systems), this approach was adopted in the absence of exact data to match identified trends within the interview sample to the present spatial area extents of olive plantations.

Land suitability dataset:

Premise - The aim was to generate a land suitability layer of use in the model also as a proxy for land value (land perceived as of high value is highly suitable and vice versa). We produced the land value surface using variables derived from the surveys and local perceptions of the respondents on what are the adding values of a field. Responses revealed the most significant determinant of a field's value to be its derived yield; reported values of annual yield for each recorded plot thus served as a proxy of land value and was used as the response variable. Responses also revealed geomorphology (aspect, elevation, slope), geology, distance to the sea, connection with the road network (accessibility) and a possible view to the sea contributed to both high yield and value of land. These eight variables thus served as the predictors.

Method - The model was built by employing the Random Forests (RF) (Breiman, 2001) which is a robust non-parametric, machine learning algorithm. We opted to use RF as it has several advantages suitable for our approach. First, RF can efficiently handle inputs with different nature and scaling (categorical, continuous) and from multiple sources (Gounaridis et al., 2015; 2016). Second, the algorithm randomly selects a part of the training (response variable) as well as a sample of predictor variables, resulting in a number of independent and identically distributed regression trees. This process is repeated until a desired number of trees is reached. Each tree casts a vote and the output is determined from the majority of votes. The randomness on the one hand and the independency of the regression trees on the other, makes RF insensitive to overfitting, collinearity issues as well as to noise and outliers (Chan and Paelinckx, 2008). Based on the first two advantages, RF allows any relevant variable to be incorporated in the model. Third, RF supports several metrics regarding the importance of the input variables (Gounaridis & Koukoulas, 2016). This allowed us to perform several tests in order to conclude to the final eight predictor variables.

The reported yield values for each respondent were classified into 3 categories according to their quartiles-distribution, normalized in kg of olives per ha and stored in a point vector layer. Outliers and no data were masked out. Aspect, and slope were derived from the Global Land Survey Digital Elevation Model (GLSDEM). Distance to the road network was computed using the Euclidean distance function and a road network layer of the area that includes the non-paved tertiary roads. Accordingly, distance from the sea computed using the Euclidean distance function and a digitized layer of the shoreline. Finally, the visibility to the sea computed using the digitized shoreline layer and the GLSDEM. All eight layers converted to raster formats at 30m spatial resolution and referred to a common projection (Greek Geodetic Reference System, 1987).

The eight predictor variables layers were collated in a database and sampled on the location of every training point (field), already containing yield category values. The model implemented through the use of the random Forest package in R (Liaw & Wiener, 2002). Generally, RF requires two parameters, the number of predictor variables randomly sampled at each split and the number of classification trees, to be specified by the user. We used three predictor variables (equal to the square root of the total number of predictor variables) for each tree split and 500 trees for each run. In the absence of real validation data for our case, the output land value layer was plotted against Google earth and interpreted visually by local experts.

(B) Sensitivity analysis and model calibration

The sensitivity analysis focused on those model attribute values that were perceived as more uncertain. The ABM is constructed around thresholds and parameters whose values are in some cases not extracted from empirical or secondary data but altered as part of model calibration. As the scope of this ABM was to explore and probe discussion around divergent landscape futures (both within scenarios and from present trends), historical data trends on demographics and rates of abandonment were not used in the model calibration but provided a baseline against which to evaluate the model results (Brown, Brown & Rousenvell, 2016). Calibration was therefore aimed at maintaining *parameter* values as close to those identified in empirical data and secondary literature while demonstrating sufficient and credible diversity between scenario storylines. **Table S4** presents the variables utilized within the model that were subjected to the one at a time (OAT) sensitivity analysis alongside the value range tested. Value ranges identified as part of the original farmer survey informed farmland area thresholds. The workshop aimed to gather information on the perceived annual number of newcomer farmers, yet no consensus was found amongst respondents, providing value ranges from 1 – 20% of the total farmer population.

Table S4- Description of uncertain model variables evaluated in OAT sensitivity analysis using set minimal and maximal values

Variable class	Variable description	Base value	Minimal value	Maximal value
New generation farmers	Annual rate of newcomers (% of run year's total population)	1%	0%	5%
	Age of new generation farmers (i.e. newcomers and successors)	18 – 38 years	18 – 28 years	18 – 48 years
	Probability of having a successor	0.3	0.1	0.5
Farmland area thresholds	Maximum farmland area threshold for all farmers	20 ha	10 ha	30 ha
	Maximum farmland area threshold for active part-timers	15 ha	7.5 ha	22.5 ha
	Minimum farmland area threshold for professionals	1 ha	0.5 ha	15 ha
	Annual decline in maximum farmland area threshold for retired farmers	-0.1 ha	-0.05 ha	-1.5 ha
Wealth	Minimum wealth required for land purchase (factor multiplying the highest value plot on sale)	50	48	52
Land value changes	Conversion costs	0.5	0.3	0.7
	Value increase / decrease from land restoration or abandonment	0.2	0.1	0.3

Action probabilities	Probability to switch to a different farmer type, expand or shrink farming system, join ILIs (factor multiplying the set probabilities – i.e. "calibration factor")	0.3	0.1	1

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8.5 Additional details on the study's results

(A) Sensitivity analysis

Table S5 – Model sensitivity to parameters in a "Bright + ILIs" scenario. Model outputs are compared to those from baseline conditions; values are averages of the final yearly time-steps from 20 complete model runs

Scenario	**BRIGHT**
ILIs	**ON**

Output	**Baseline**	**% Change farmers**	**Baseline**	**% Abandoned fields**	**Baseline**	**% Intensified fields**	**Baseline**	**% De-intensified fields**	**Baseline**	**% Active part-timers**	**Baseline**	**% Detached farmers**	**Baseline**	**% Professional**
Age of newcomers (min)	-12	-13	42	42	82	82	3	3	30	30	18	18	51	52
Age of newcomers (max)	-12	-13	42	43	82	82	3	3	30	31	18	18	51	51
Land value (min)	-12	-12	42	41	82	82	3	3	30	30	18	18	51	51
Land value (max)	-12	-13	42	39	82	82	3	3	30	31	18	18	51	52
Conversion cost (min)	-12	-13	42	41	82	81	3	3	30	30	18	18	51	51
Conversion cost (max)	-12	-13	42	41	82	82	3	3	30	31	18	18	51	51
Calibration-factor (min	-12	-19	42	52	82	60	3	4	30	37	18	35	51	28
Calibration-factor (max)	-12	-20	42	29	82	89	3	2	30	27	18	8	51	65
Minimum wealth (min)	-12	-13	42	41	82	82	3	3	30	31	18	18	51	51
Minimum wealth (max)	-12	-13	42	44	82	82	3	3	30	31	18	18	51	52
% Newcomers (min)	-12	-32	42	47	82	84	3	4	30	36	18	9	51	55
% Newcomers (max)	-12	131	42	5	82	69	3	2	30	20	18	43	51	37
Probability successor (min)	-12	-21	42	49	82	82	3	2	30	32	18	19	51	49
Probability successor (max)	-12	-11	42	39	82	82	3	3	30	30	18	18	51	52
Maximum farm area all (min)	-12	-12	42	39	82	81	3	3	30	31	18	18	51	51
Maximum farm area all (max)	-12	-13	42	42	82	81	3	3	30	31	18	18	51	51
Minimum area active part-timers (min)	-12	-12	42	41	82	81	3	3	30	30	18	18	51	52
Minimum area active part-timers (max)	-12	-12	42	40	82	81	3	4	30	31	18	18	51	50
Maximum area professionals (min)	-12	-13	42	42	82	82	3	3	30	31	18	18	51	51
Maximum area professionals (max)	-12	-13	42	43	82	81	3	3	30	30	18	18	51	52
Area decline retirees (min)	-12	-13	42	40	82	82	3	3	30	31	18	18	51	51
Area decline retirees (max)	-12	-13	42	41	82	82	3	3	30	31	18	18	51	51

Table S6 - Model sensitivity to parameters in a "Bright - ILIs" scenario. Model outputs are compared to those from baseline conditions; values are averages of the final yearly time-steps from 20 complete model runs

Scenario	**BRIGHT**													
ILIs	**OFF**													
Output	**Baseline**	**% Change farmers**	**Baseline**	**% Abandoned fields**	**Baseline**	**% Intensified fields**	**Baseline**	**% De-intensified fields**	**Baseline**	**% Active part-timers**	**Baseline**	**% Detached farmers**	**Baseline**	**% Professional**
Age of newcomers (min)	-31	-31	60	59	18	18	8	8	34	34	37	37	29	29
Age of newcomers (max)	-31	-31	60	59	18	18	8	8	34	37	37	36	29	27
Land value (min)	-31	-31	60	60	18	17	8	8	34	35	37	37	29	28
Land value (max)	-31	-32	60	58	18	18	8	8	34	34	37	36	29	29
Conversion cost (min)	-31	-31	60	60	18	18	8	8	34	34	37	37	29	29
Conversion cost (max)	-31	-31	60	59	18	18	8	8	34	34	37	37	29	29
Calibration-factor (min	-31	-30	60	60	18	14	8	8	34	36	37	42	29	22
Calibration-factor (max)	-31	-40	60	62	18	15	8	8	34	33	37	38	29	29
Minimum wealth (min)	-31	-31	60	58	18	18	8	8	34	34	37	37	29	29
Minimum wealth (max)	-31	-31	60	60	18	17	8	8	34	34	37	37	29	29
% Newcomers (min)	-31	-50	60	66	18	16	8	9	34	44	37	25	29	31
% Newcomers (max)	-31	107	60	19	18	23	8	5	34	17	37	61	29	23
Probability successor (min)	-31	-32	60	60	18	18	8	8	34	35	37	37	29	29
Probability successor (max)	-31	-31	60	60	18	18	8	8	34	35	37	36	29	29
Maximum farm area all (min)	-31	-32	60	60	18	18	8	8	34	34	37	37	29	29
Maximum farm area all (max)	-31	-31	60	60	18	18	8	8	34	34	37	37	29	29
Minimum area active part-timers (min)	-31	-32	60	60	18	17	8	8	34	33	37	37	29	30
Minimum area active part-timers (max)	-31	-32	60	60	18	18	8	8	34	35	37	37	29	29
Maximum area professionals (min)	-31	-32	60	60	18	18	8	8	34	34	37	37	29	29
Maximum area professionals (max)	-31	-31	60	59	18	17	8	8	34	35	37	37	29	28
Area decline retirees (min)	-31	-32	60	60	18	18	8	8	34	34	37	37	29	30
Area decline retirees (max)	-31	-31	60	60	18	18	8	8	34	34	37	37	29	29

Table S7 – Model sensitivity to parameters in a "Doom + ILIs" scenario. Model outputs are compared to those from baseline conditions; values are averages of the final yearly time-steps from 20 complete model runs

Scenario	**DOOM**													
ILIs	**ON**													
Output	**Baseline**	**% Change farmers**	**Baseline**	**% Abandoned fields**	**Baseline**	**% Intensified fields**	**Baseline**	**% De-intensified fields**	**Baseline**	**% Active part-timers**	**Baseline**	**% Detached farmers**	**Baseline**	**% Professional**
Age of newcomers (min)	-58	-58	79	79	81	82	5	5	22	22	33	33	45	45
Age of newcomers (max)	-58	-57	79	78	81	80	5	5	22	22	33	33	45	46
Land value (min)	-58	-58	79	79	81	81	5	5	22	22	33	33	45	45
Land value (max)	-58	-57	79	78	81	81	5	5	22	22	33	33	45	45
Conversion cost (min)	-58	-58	79	79	81	81	5	5	22	22	33	33	45	44
Conversion cost (max)	-58	-58	79	79	81	80	5	6	22	22	33	33	45	45
Calibration-factor (min	-58	-33	79	64	81	58	5	5	22	32	33	41	45	26
Calibration-factor (max)	-58	-93	79	97	81	56	5	2	22	5	33	65	45	30
Minimum wealth (min)	-58	-58	79	79	81	82	5	5	22	22	33	32	45	46
Minimum wealth (max)	-58	-58	79	79	81	81	5	5	22	22	33	33	45	45
% Newcomers (min)	-58	-68	79	81	81	85	5	6	22	25	33	22	45	53
% Newcomers (max)	-58	13	79	62	81	66	5	3	22	15	33	57	45	27
Probability successor (min)	-58	-61	79	80	81	80	5	5	22	24	33	35	45	41
Probability successor (max)	-58	-57	79	78	81	81	5	6	22	22	33	33	45	45
Maximum farm area all (min)	-58	-58	79	79	81	81	5	5	22	22	33	32	45	46
Maximum farm area all (max)	-58	-58	79	79	81	81	5	5	22	22	33	33	45	45
Minimum area active part-timers (min)	-58	-58	79	79	81	81	5	5	22	21	33	33	45	46
Minimum area active part-timers (max)	-58	-58	79	79	81	81	5	5	22	23	33	33	45	43
Maximum area professionals (min)	-58	-58	79	79	81	81	5	5	22	22	33	33	45	45
Maximum area professionals (max)	-58	-57	79	78	81	80	5	5	22	22	33	33	45	45
Area decline retirees (min)	-58	-59	79	79	81	82	5	5	22	22	33	32	45	45
Area decline retirees (max)	-58	-58	79	79	81	80	5	5	22	22	33	34	45	45

Table S8 – Model sensitivity to parameters in a "Doom – ILIs" scenario. Model outputs are compared to those from baseline conditions; values are averages of the final yearly time-steps from 20 complete model runs

Scenario	**DOOM**														
ILIs	**OFF**														
Output	**Baseline**	**% Change farmers**	**Baseline**	**% Abandoned fields**	**Baseline**	**% Intensified fields**	**Baseline**	**% De-intensified fields**	**Baseline**	**% Active part-timers**	**Baseline**	**% Detached farmers**	**Baseline**	**% Professional**
Age of newcomers (min)	-58	-57	78	78	14	15	11	11	20	20	61	60	19	20
Age of newcomers (max)	-58	-58	78	78	14	16	11	11	20	21	61	58	19	20
Land value (min)	-58	-58	78	78	14	15	11	11	20	20	61	61	19	19
Land value (max)	-58	-58	78	78	14	15	11	11	20	20	61	60	19	20
Conversion cost (min)	-58	-58	78	78	14	14	11	11	20	20	61	61	19	20
Conversion cost (max)	-58	-58	78	78	14	14	11	12	20	20	61	60	19	20
Calibration-factor (min	-58	-40	78	68	14	13	11	10	20	31	61	49	19	20
Calibration-factor (max)	-58	-72	78	85	14	4	11	13	20	8	61	80	19	12
Minimum wealth (min)	-58	-57	78	78	14	14	11	11	20	20	61	61	19	20
Minimum wealth (max)	-58	-58	78	78	14	14	11	12	20	20	61	61	19	19
% Newcomers (min)	-58	-70	78	81	14	14	11	13	20	26	61	50	19	23
% Newcomers (max)	-58	22	78	59	14	19	11	6	20	11	61	76	19	13
Probability successor (min)	-58	-58	78	78	14	15	11	11	20	20	61	61	19	20
Probability successor (max)	-58	-58	78	78	14	14	11	11	20	20	61	61	19	19
Maximum farm area all (min)	-58	-57	78	78	14	14	11	11	20	20	61	60	19	20
Maximum farm area all (max)	-58	-58	78	78	14	14	11	11	20	19	61	61	19	20
Minimum area active part-timers (min)	-58	-57	78	78	14	14	11	11	20	20	61	61	19	19
Minimum area active part-timers (max)	-58	-58	78	78	14	14	11	12	20	20	61	61	19	19
Maximum area professionals (min)	-58	-58	78	78	14	15	11	11	20	20	61	61	19	19
Maximum area professionals (max)	-58	-58	78	78	14	15	11	11	20	20	61	61	19	19
Area decline retirees (min)	-58	-58	78	78	14	14	11	11	20	20	61	61	19	19
Area decline retirees (max)	-58	-57	78	78	14	14	11	11	20	20	61	61	19	19

Table S9 - Model sensitivity to parameters changed by multi-level drivers under Bright conditions. Model outputs are compared to those from baseline conditions; values are averages of the final yearly time-steps from 20 complete model runs

Scenario	BRIGHT
ILIs	ON

Output	Baseline	% Change farmers	Baseline	% Abandoned fields	Baseline	% De-intensified plots	Baseline	% Intensified plots	Baseline	% Active part-timers	Baseline	% Detached farmers	Baseline	% Professional	Baseline	% ILI members	Baseline	% New generation
Management Intensity	-12	-12	42	43	3	6	82	34	30	31	18	18	51	51	74	74	71	71
Probability of successor	-12	-32	42	60	3	1	82	83	30	40	18	22	51	38	74	79	71	40
Consulting	-12	-13	42	41	3	3	82	82	30	30	18	18	51	52	74	74	71	71
Culturally driven	-12	-12	42	42	3	3	82	82	30	27	18	32	51	41	74	73	71	71
Olive oil price	-12	-16	42	48	3	4	82	80	30	30	18	18	51	52	74	75	71	31
Subsidies	-12	-13	42	46	3	3	82	81	30	30	18	18	51	51	74	74	71	71
Labor wages																		

Scenario	BRIGHT
ILIs	OFF

Output	Baseline	% Change farmers	Baseline	% Abandoned fields	Baseline	% De-intensified plots	Baseline	% Intensified plots	Baseline	% Active part-timers	Baseline	% Detached farmers	Baseline	% Professional	Baseline	% ILI members	Baseline	% New generation
Management Intensity																		
Probability of successor																		
Consulting																		
Culturally driven																		
Olive oil price	-31	-32	60	61	8	9	18	17	34	33	37	38	29	29	7	8	41	11
Subsidies	-31	-31	60	60	8	8	18	18	34	33	37	38	29	29	7	7	41	41
Labor wages																		

Table S10 - Model sensitivity to parameters changed by multi-level parameters under Doom conditions. Model outputs are compared to those from baseline conditions; values are averages of the final yearly time-steps from 20 complete model runs

Scenario	DOOM
ILIs	ON

Output	Baseline	% Change farmers	Baseline	% Abandoned fields	Baseline	% De-intensified plots	Baseline	% Intensified plots	Baseline	% Active part-timers	Baseline	% Detached farmers	Baseline	% Professional	Baseline	% ILI members	Baseline	% New generation
Management Intensity	-58	-59	79	79	5	7	81	42	22	22	33	33	45	45	63	62	71	71
Probability of successor	-58	-67	79	83	5	3	81	80	22	32	33	40	45	28	63	66	71	40
Consulting	-58	-58	79	79	5	5	81	80	22	22	33	33	45	45	63	61	71	71
Culturally driven	-58	-47	79	72	5	5	81	81	22	15	33	55	45	30	63	65	71	70
Olive oil price																		
Subsidies	-58	-47	79	71	5	4	81	82	22	29	33	27	45	44	63	67	71	70
Labor wages	-58	-57	79	78	5	5	81	81	22	21	33	32	45	46	63	64	71	71

Scenario	DOOM
ILIs	OFF

Output	Baseline	% Change farmers	Baseline	% Abandoned fields	Baseline	% De-intensified plots	Baseline	% Intensified plots	Baseline	% Active part-timers	Baseline	% Detached farmers	Baseline	% Professional	Baseline	% ILI members	Baseline	% New generation
Management Intensity																		
Probability of successor																		
Consulting																		
Culturally driven																		
Olive oil price																		
Subsidies	-58	-52	78	75	11	11	14	13	20	26	61	54	19	20	6	7	41	40
Labor wages	-58	-57	78	78	11	12	14	14	20	20	61	60	19	20	6	6	41	40

(B) Stakeholder evaluation of the workshop process

63% of cultural landscape experts felt the process and visualization of outcomes was difficult to understand, suggesting photo perspectives could facilitate the communication process. All but one local farming community participant agreed the model allowed for a dual learning and sharing experience, the remaining participant stating uncertainty. A participant specifically valued the exchange of perspectives between the non-scientific and scientific communities that emerged from the selected variables. Over 90% of respondents agreed on both the usefulness of thinking of scenarios for preservation of the local agricultural landscapes and of utilizing models as tools for discussing the future of the area, with one participant stating "the presented actions are important and useful for the value of Gera, while at the same time providing insights and motivation for the younger generation to do something for their land". 64% of respondents stated it was "relatively easy" to understand the model processes and outcomes, with one participant stating uncertainty and the remaining participant "relative difficulty".

(C) Spatial results on locational stability

Table S11 – Mean land suitability and extent of hotspot areas belonging to each of the three farmer types, values are averages of 20 model runs following a 25 year simulation under two contrasting Doom and Bright scenarios, with and without the implementation of ILIs

	Plot ownership									
	Active part-timers			**Detached farmers**			**Professionals**			**Combined hotspot area (% of total cultivated)**
	Mean land suitability of hotspot plots	***St. Dev.***	**Hotspot area (% of type's majority area)**	**Mean land suitability of hotspot plots**	***St. Dev.***	**Hotspot area (% of type's majority area)**	**Mean land suitability of hotspot plots**	***St. Dev.***	**Hotspot area (% of type's majority area)**	
B + ILI	0.348	*0.04*	**40**	0.334	*0.03*	**15**	0.358	*0.05*	**17**	22
B – ILI	0.351	*0.04*	**36**	0.346	*0.04*	**17**	0.358	*0.06*	**0**	20
D + ILI	0.354	*0.04*	**70**	0.353	*0.05*	**7**	0.362	*0.05*	**6**	20
D – ILI	0.354	*0.04*	**22**	0.353	*0.05*	**28**	-	-	**0**	21

Table S12 – Mean land suitability and extent of hotspot areas of abandoned and cultivated land cover classes, values are averages of 20 model runs following a 25 year simulation under two contrasting Doom and Bright scenarios, with and without the implementation of ILIs

	Land cover class												
	Short-term abandoned			**Long-term abandoned**			**Intensified**			**De-intensified**			
	Mean land suitability of hotspot plots	***St. Dev.***	**Hotspot area (% of majority class area)**	**Mean land suitability of hotspot plots**	***St. Dev.***	**Hotspot area (% of majority class area)**	**Mean land suitability of hotspot plots**	***St. Dev.***	**Hotspot area (% of majority class area)**	**Mean land suitability of hotspot plots**	***St. Dev.***	**Hotspot area (% of majority class area)**	**Combined hotspot area (% of total area)**
B + ILI	-	-	-	0.335	*0.04*	**25**	0.360	*0.05*	**11**	-	-	-	22
B – ILI	0.344	*0.04*	**76**	0.349	*0.04*	**17**	0.358	*0.04*	**57**	0.410	*0.00*	**33**	34
D + ILI	0.353	*0.05*	**1**	0.350	*0.04*	**38**	0.409	*0.02*	**25**	-	-	-	24
D – ILI	0.349	*0.05*	**22**	0.352	*0.04*	**25**	-	-	-	-	-	-	25

8.6 Stakeholder workshop – local farming community questionnaire

(A) Please state your level of agreement with the following statement:

	Farmers choose to buy plots with the highest land suitability, and sell or abandon plots with the lowest land suitability * ***(proximity to existing plots is therefore not considered when buying)***
	☐ Strongly disagree ☐ Disagree ☐ Unsure ☐ Agree ☐ Completely agree Please explain your answer: ______ Under what conditions would this not be the case? ______ ______

***Land suitability** is a measure of the plots: *elevation, slope, aspect, distance from roads, village centers and from the sea, geology and view from plot*

(B) **Please check the box which best describes your sentiments towards the following values and thresholds used within the model:**

1	**Number of new farmers in Gera every year (as a % of the total farming population and NOT including successors)**					**I think it's close to …**
	? %	☐ Too low	☐ Too high	☐ Looks right	☐ Unsure	____***%***
2	**% of the total farming population which would join local initiatives* if they were implemented now**					**I think it's closer to …**
	10%	☐ Too low	☐ Too high	☐ Looks right	☐ Unsure	____***%***
3	**Proportion of the farming population which will not have joined local initiatives, nor changed behavior or management at the end of the Tourism & Conservation Scenario (in 25 years' time)**					**I think it's closer to …**
	70%	☐ Too low	☐ Too high	☐ Looks right	☐ Unsure	____***%***
4	**Under a Business As Usual scenario, local initiatives gain ground and are implemented in …**					**I think it's closer to …**
	15 years	☐ Too low	☐ Too high	☐ Looks right	☐ Unsure	_____ ***years***

*__**Local initiatives**__ represent initiatives building on cooperation between farmers and multiple regional sectors, focusing on the role of cultural heritage in promoting conservation of the local agricultural landscapes and sector (by means of entrepreneurial innovation, sustainable land management, certification of produce, branding and labelling etc.)

(C) For each question describing a model process, please state which variable you feel is most important by placing a number in the variable's respective box as follows:

> ***1 = least important***
> ***5 = most important (or 3 or 4 depending on the number of variables in the question)***
> ***0 = not important at all***

If you feel all or some variables have equal importance, give them the same number

1	**Drivers affecting the emergence and success of local initiatives**					**Anything else?**
	☐ Price of olive oil	☐ Agricultural subsidies	☐ Labor wages	☐ Availability of land	☐ Accessibility of land	☐
2	**Factors affecting annual yield of a farmer's plot**					**Anything else?**
	☐ Slope	☐ Management intensity	☐ Hired labor			☐
3	**Factors affecting annual costs of a farmer's plot**					**Anything else?**
	☐ Transport costs	☐ Management costs	☐ Hired labor (labor wages)			☐
4	**Factors affecting decision to EXPAND farm *(excluding wealth, farm area and past profits)***					**Anything else?**
	☐ Past actions	☐ Age	☐ Consultation with external sources or other farmers			☐
5	**Factors affecting decision to SHRINK farm *(excluding wealth, farm area and past profits)***					**Anything else?**
	☐ Past actions	☐ Age	☐ Cultural drive	☐ Education level		☐

(D) Other factors not included in the present model are shaping social and environmental processes on the island of Lesvos today. To what extent would climate change, the present political situation and migration crisis change the modelled scenarios presented? If you agree they would, can you specify how?

	Climate					How?
1	☐ Would not at all alter the modelled processes	☐ Would not alter the modelled processes	☐ Unsure	☐ Would alter the modelled processes	☐ Would greatly alter the modelled processes	
	Politics					
2	☐ Strongly disagree	☐ Disagree	☐ Unsure	☐ Agree	☐ Completely agree	
	Migration					
3	☐ Strongly disagree	☐ Disagree	☐ Unsure	☐ Agree	☐ Completely agree	

(E) Please state the level of agreement with the following statements by ticking the most appropriate box:

1	**Thinking of scenarios for the future is important for preservation of the local agricultural landscapes**					**Any comments:**
	☐ Strongly disagree	☐ Disagree	☐ Unsure	☐ Agree	☐ Completely agree	
2	**Simulation models as shown in the session are a helpful tool for discussing the future of the area**					**Any comments:**
	☐ Strongly disagree	☐ Disagree	☐ Unsure	☐ Agree	☐ Completely agree	
3	**The scenarios and models did capture the local situation in a realistic and credible manner**					**Any comments:**
	☐ Strongly disagree	☐ Disagree	☐ Unsure	☐ Agree	☐ Completely agree	Which ones were? Which ones were not?
4	**This workshop session allowed me to both share and acquire new knowledge**					**Any comments:**
	☐ Strongly disagree	☐ Disagree	☐ Unsure	☐ Agree	☐ Completely agree	

(F) How would you describe the ease with which it was possible to understand the model processes and outcome posters?

☐ Very difficult	☐ Relatively difficult	☐ Unsure	☐ Relatively easy	☐ Very easy

(G) Thank you for participating in the survey. Do you have any additional comments or feedback on the model processes, the visual outputs or the workshop session? Please specify below:

8.7 Stakeholder workshop – cultural landscape expert questionnaire

(A) Olive oil prices, agricultural subsidies, labor wages, land availability and accessibility of olive fields were conceptualized as the "enabling drivers" to the emergence and success of local initiatives*. To what extent do you think, based on your knowledge, this is a correct simplification of reality?

☐	☐	☐	☐	☐
Strongly disagree	Disagree	Unsure	Agree	Completely agree

Do you see other key drivers? Are some of these more important than others?

Please explain your answer: ____

____

____

(B) Local initiatives do not emerge under an "Agricultural Liberalization" scenario because of the state of the enabling drivers (gradual reduction of subsidies, no improvements to road infrastructure and increased rural depopulation). To what extent do you agree this is an appropriate assumption?

☐	☐	☐	☐	☐
Strongly disagree	Disagree	Unsure	Agree	Completely agree

Please explain your answer: ____

____

____

*__Local initiatives__ represent initiatives building on cooperation between farmers and multiple regional sectors, focusing on the role of cultural heritage in promoting conservation of the local agricultural landscapes and sector (by means of entrepreneurial innovation, sustainable land management, certification of produce, branding and labelling etc.)

(C) How realistic is the increased land availability seen in the "Tourism & Conservation" scenario, achieved via the introduction of abandoned plots in the land market?

Please explain your answer: ______________________________

____

____

(D) What specifically could facilitate the scaling up of local initiatives and would you consider this important for representation in the model?

Please explain your answer: ______________________________

____

____

(E) What other scenarios could you imagine for the region that would be important to consider and were not addressed?

Please explain your answer: ______________________________

____

____

(F) What other factors/processes should be included in the model (under the present or your own imagined scenarios) that were not included in the current simulations?

Please explain your answer: ______________________________

____

____

(G) Please state your level of agreement with the following statements by ticking the most appropriate box:

1	**Thinking of scenarios for the future is important for preservation of the local agricultural landscapes**					**Any comments:**
	☐ Strongly disagree	☐ Disagree	☐ Unsure	☐ Agree	☐ Completely agree	
2	**Results of simulation models as shown in the session are a helpful tool for discussing the future of the area**					**Any comments:**
	☐ Strongly disagree	☐ Disagree	☐ Unsure	☐ Agree	☐ Completely agree	
3	**The scenarios and models did capture the local situation in a realistic and credible manner**					**Any comments:**
	☐ Strongly disagree	☐ Disagree	☐ Unsure	☐ Agree	☐ Completely agree	Which ones were? Which ones were not?
4	**This workshop session allowed me to both share and acquire new knowledge**					**Any comments:**
	☐ Strongly disagree	☐ Disagree	☐ Unsure	☐ Agree	☐ Completely agree	

(H) How would you describe the ease with which it was possible to understand the model processes and outcome posters?

☐ Very difficult	☐ Relatively difficult	☐ Unsure	☐ Relatively easy	☐ Very easy

(I) Thank you for participating in the survey. Do you have any additional comments or feedback on the model processes, the visual outputs or the workshop session? Please specify below: